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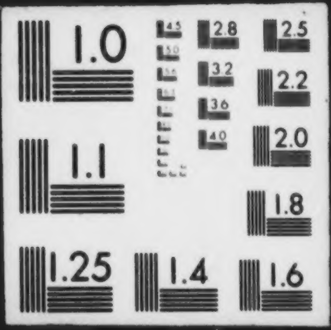

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Washington, D. C.

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In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

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Reports

Gross Radioactivity of the Solids in Selected Surface Waters of the United States, 1961-1965

Elmo C. Julian [1]

Gross radioactivity has been expressed in pCi/liter of water but to understand the movement of radiological contamination in the absence of flow data, the consideration of radioactivity in the suspended and dissolved solids in pCi/g is quite useful. The gross radioactivity of the solids in some surface waters of the United States is presented and interpreted in this report with the data from stations of the Water Pollution Surveillance System for the years 1961 through 1965.

Radioactivity levels in surface waters as modified by seasonal runoff patterns are reported. The radioactivity of solids collected below two production reactor facilities was measured and a trend is indicated.

The history of the monitoring of gross radioactivity in surface waters of the United States and the analytical methods employed have been described in reports by the former Division of Water Supply and Pollution Control of the U.S. Public Health Service, now the Federal Water Pollution Control Administration, U.S. Department of the Interior (*1*). Water quality is customarily expressed in the form of weight per unit volume (mg/liter). A water sample as obtained from a stream will contain solid material in suspension and this suspended material is considered a part of the water of the stream for defining the water quality. Gross beta radioactivity associated with the suspended solids is not highly significant for domestic water use since nearly all suspended matter is removed in most instances by municipal water treatment processes (*2*). The presence of large quantities of suspended solids leads to proportionately large values for the gross radioactivity, since gross radioactivity levels in water are expressed only in picocuries per liter (pCi/liter). These complications have been recognized and discussed (*2,3*). This effect is illustrated below for a sample collected October 18, 1966, from Laredo, Tex., on the Rio Grande.

	Solids (mg/liter)	Water quality (pCi/liter)		Solids quality (pCi/g)	
		Alpha radioactivity	Beta radioactivity	Alpha radioactivity	Beta radioactivity
Dissolved solids...	536	4 ± 2	26 ± 2	7 ± 4	49 ± 4
Suspended solids...	5,590	125 ± 41	305 ± 43	22 ± 7	55 ± 7

If a nuclear facility adds highly radioactive materials to a stream, the resulting weight of solid radioactive material is negligible when compared to the weight of solids already present in the stream; consequently, the radioactivity in picocuries per gram will increase. To recognize significant changes of radioactivity in water, the calculation of results as picocuries per gram is required. The reporting of gross radioactivity in the surface waters of the United States has included no discussion of gross radioactivity on the weight basis (*4*).

In this report, the gross radioactivity in pCi/liter is considered as water quality and in pCi/gram as solids quality.

---

[1] Mr. Julian is in charge of the Radiochemistry Unit of the Water Quality Activities, Division of Pollution Surveillance, Federal Water Pollution Control Administration, U.S. Department of the Interior, 1014 Broadway, Cincinnati, Ohio 45202.

The following radiological characteristics of the solids are considered:

1. Natural radioactivity—The natural radioactivity results from naturally occurring radionuclides such as potassium-40, thorium-232, uranium-238, and other decay products from uranium and thorium.
2. Fallout—This radioactive material consists of insoluble and soluble fission products and neutron-activated materials from nuclear weapons tests.
3. Reactor material—Production reactors in their operation yield, in addition to fission products, neutron-activated materials which must be disposed of as waste material. After appropriate decay periods and dilutions, these wastes may be safely discharged to the stream.
4. Uranium and thorium mining and milling wastes—these operations may release a variety of decay products, such as radium.

This study is divided into two parts. In the first part, twelve stations of the Water Pollution Surveillance System (WPSS) on eleven rivers were selected to show water quality and solids quality near the mouth of each river and at a few upstream locations. Solids quality data were calculated from existing water quality data for the period July 1, 1961 through September 30, 1965. Tables 1 through 5 summarize these data. The data in all the tables and figures are reported at the 2 σ counting error level. The Pasco, Wash., and Port Wentworth, Ga., stations are downstream from production reactor complexes. Data from these stations are given, but are omitted from the general averages and are treated separately. To show a geographical perspective, the station locations are shown in figure 1.

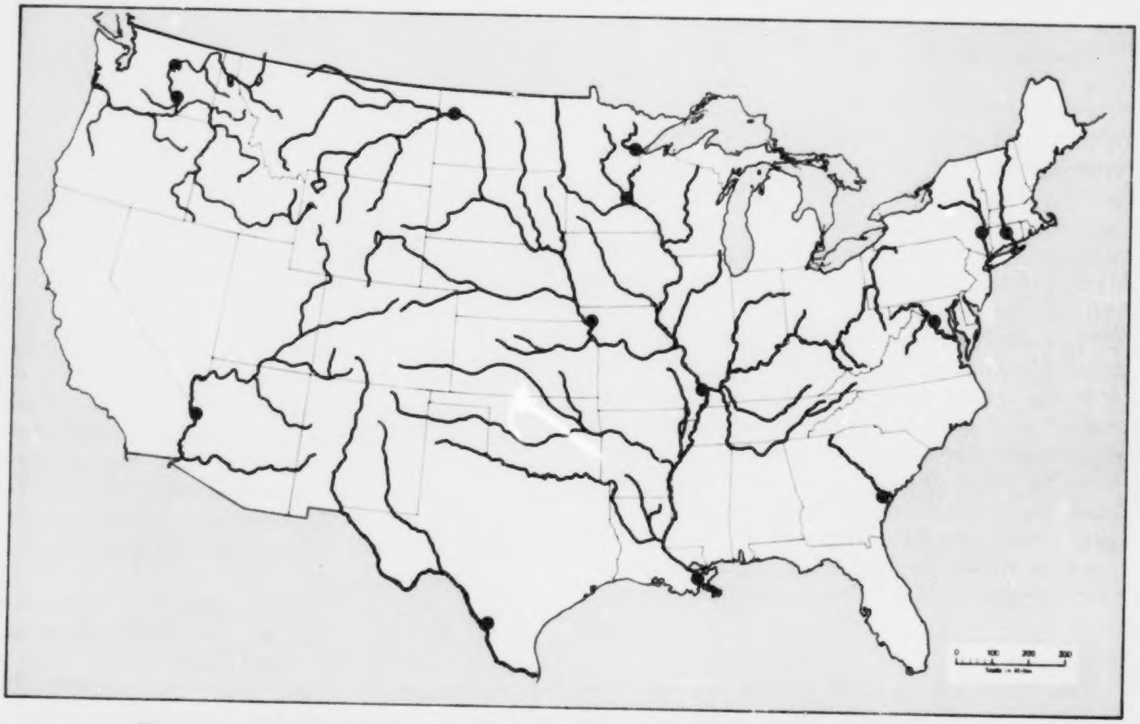

Figure 1. Selected stations of the Water Pollution Surveillance System for a study of gross radioactivity of the solids in the waters of the United States, 1961-1965

Table 1. Alpha radioactivity in suspended solids

Station	1961				1962								1963								1964								1965					
	July-Sept		Oct-Dec		Jan-Mar		Apr-June		July-Sept		Oct-Dec		Jan-Mar		Apr-June		July-Sept		Oct-Dec		Jan-Mar		Apr-June		July-Sept		Oct-Dec		Jan-Mar		Apr-June		July-Sept	
	pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/	
	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g
Connecticut River: Enfield Dam, Conn.									1	13	0	0	0	4	0	5	0	11	0	0	0	0	0	8	0	0	1	25	0	0	0	7	0	0
Hudson River: Poughkeepsie, N. Y.	0	0	0	4	0	0	0	4	1	19	1	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	3	0	0	0	0
Potomac River: Washington, D. C.																	0	0	0	8	1	6	0	6	0	0	1	14	4	22	0	0	0	0
Savannah River: Port Wentworth, Ga.	1	9	0	10	0	7	0	0	0	10	0	0	1	17	0	0	0	6	0	0	0	7	1	9	0	3	0	8	0	9	0	4	0	9
Lake Superior: Duluth, Minn.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mississippi River: St. Paul, Minn.	1	7	0	0	0	9	0	4	1	6	0	0	0	9	0	8	0	5	0	0	0	0	0	0	0	11	0	11	0	0	0	7	0	7
New Orleans, La.	1	12	7	15	5	20	3	15	0	9	0	5	3	16	1	8	0	0	0	0	3	18	5	18	1	7	1	11	5	18	16	42	4	19
Missouri River: Williston, N. Dak.	4	12	5	15	1	10	79	14	0	0	2	6	2	13	2	15	1	13	1	4	1	7	2	13	1	14	2	8	2	6	2	15	1	16
St. Joseph, Mo.	17	19	2	5	3	8	25	24	3	10	4	7	15	11	33	16	7	19	2	18	1	3	23	16	16	19	3	10	13	14	21	15	18	19
Ohio River: Cairo, Ill.	3	29	2	11	3	14	5	15	0	0	4	48	15	74	5	54	1	11	1	18	7	45	4	24	0	7	3	20	6	24	2	12	0	11
Rio Grande: Laredo, Tex.	20	19	2	9	1	4	2	4	35	10	6	4	1	3	17	8	29	16	13	17	1	4	74	13	27	10	4	9	0	6	11	9	9	9
Colorado River: Parker Dam, Ariz.	1	6	0	0	1	2	1	2	0	2	1	6	0	0	1	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Columbia River: Wenatchee, Wash.	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pasco, Wash.	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	10	0	0	0	0	0	5	0	0	0	0	0	3	0	2	0	0
Average [a]	6	10	2	6	1	7	12	8	4	6	2	9	3	12	5	11	3	6	1	5	1	7	9	8	4	6	1	10	3	8	4	9	3	7

[a] Except for Port Wentworth, Ga., and Pasco, Wash.

Table 2. Alpha radioactivity in dissolved solids

Station	1961				1962								1963								1964								1965					
	July-Sept		Oct-Dec		Jan-Mar		Apr-June		July-Sept		Oct-Dec		Jan-Mar		Apr-June		July-Sept		Oct-Dec		Jan-Mar		Apr-June		July-Sept		Oct-Dec		Jan-Mar		Apr-June		July-Sept	
	pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/	
	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g
Connecticut River: Enfield Dam, Conn.	......	......	......	......	......	......	......	......	0	0	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hudson River: Poughkeepsie, N. Y.	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2	0	2	0	1	0	1	0	0	1	2	1	2	0	0	0	0	0	0
Potomac River: Washington, D. C.	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	0	1	0	2	0	1	0	1	0	1	1	3	0	0	0	3	0	3
Savannah River: Port Wentworth, Ga.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	2	0	0	0	0
Lake Superior: Duluth, Minn.	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mississippi River: St. Paul, Minn.	2	6	1	3	1	4	2	6	2	6	0	1	1	4	2	6	2	6	2	7	1	2	2	5	2	6	2	5	2	7	2	8	1	4
New Orleans, La.	0	0	1	4	1	4	1	6	1	4	2	7	0	1	0	1	2	6	1	4	1	2	1	5	1	4	1	5	1	3	1	5	1	4
Missouri River: Williston, N. Dak.	3	6	5	10	2	6	4	9	2	5	3	5	5	10	5	9	3	6	5	9	5	11	4	7	3	7	6	11	6	12	3	8	4	16
St. Joseph, Mo.	4	8	5	10	3	7	2	5	3	6	6	12	4	9	5	30	4	10	4	7	4	9	3	7	5	9	5	10	3	9	4	9	4	8
Ohio River: Cairo, Ill.	1	4	0	0	1	4	0	1	0	1	1	3	1	3	0	0	0	1	0	1	1	4	0	0	1	3	1	4	0	0	0	1	0	0
Rio Grande: Laredo, Tex.	4	6	4	7	2	2	2	3	4	7	6	10	4	4	2	2	5	7	5	8	4	6	2	4	2	3	3	6	4	7	3	5	3	6
Colorado River: Parker Dam, Ariz.	7	9	7	9	7	9	7	8	8	10	7	9	9	11	7	10	7	9	10	15	7	9	11	14	7	8	7	12	9	11	7	9	8	10
Columbia River: Wenatchee, Wash.	1	2	1	11	1	5	1	11	0	0	1	7	1	11	1	4	1	5	0	4	1	8	0	3	0	0	1	6	1	10	1	5	0	3
Pasco, Wash.	0	1	0	3	1	9	1	2	0	0	1	5	1	6	1	5	0	0	0	4	1	7	0	5	0	3	1	7	1	6	1	6	1	5
Average [a]	2	4	2	5	2	4	2	5	2	4	2	5	2	5	2	6	2	4	2	5	2	4	2	4	2	4	2	5	2	5	2	4	2	5

[a] Except for Port Wentworth, Ga., and Pasco, Wash.

Table 3. Beta radioactivity in suspended solids

Station	1961				1962								1963								1964								1965					
	July-Sept		Oct-Dec		Jan-Mar		Apr-June		July-Sept		Oct-Dec		Jan-Mar		Apr-June		July-Sept		Oct-Dec		Jan-Mar		Apr-June		July-Sept		Oct-Dec		Jan-Mar		Apr-June		July-Sept	
	pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/	
	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g
Connecticut River: Enfield Dam, Conn.	----	----	----	----	----	----	----	----	9	340	8	221	16	354	11	211	12	302	9	358	5	147	2	55	3	91	3	70	7	223	2	49	2	83
Hudson River: Poughkeepsie, N. Y.	3	52	6	94	17	482	6	104	4	136	8	192	11	275	8	183	2	92	2	83	5	145	3	84	6	129	3	70	4	73	2	57	1	31
Potomac River: Washington, D. C.	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	6	122	4	116	8	124	4	75	2	50	1	30	14	86	0	10	1	23
Savannah River: Port Wentworth, Ga.	6	104	5	120	25	519	13	312	7	156	7	171	26	490	23	364	14	328	4	207	7	205	14	202	7	171	4	92	4	89	3	86	3	106
Lake Superior: Duluth, Minn.	1	43	2	79	6	252	5	110	4	137	2	81	5	123	2	31	2	42	2	63	1	21	3	103	1	35	0	0	3	65	1	24	1	44
Mississippi River: St. Paul, Minn.	2	7	14	446	5	137	25	247	14	211	7	164	6	154	28	342	8	188	4	114	2	75	10	166	3	90	3	106	1	36	4	93	2	53
New Orleans, La.	2	17	29	146	59	233	55	195	13	116	15	201	31	197	37	232	4	5	1	25	16	123	31	98	8	67	6	58	23	94	30	85	14	66
Missouri River: Williston, N. Dak.	21	44	16	97	14	94	362	231	100	126	109	101	26	169	26	210	12	178	10	110	6	95	18	139	5	68	5	32	13	60	8	74	5	63
St. Joseph, Mo.	41	42	91	269	92	151	251	164	131	152	23	84	89	99	299	159	48	130	11	76	7	44	154	162	55	61	14	69	37	60	90	64	51	57
Ohio River: Cairo, Ill.	6	69	24	126	81	400	30	199	3	104	10	88	125	408	41	421	2	46	1	35	37	202	23	159	3	59	5	49	20	87	7	84	1	35
Rio Grande: Laredo, Tex.	42	31	35	74	9	54	48	147	362	122	112	278	22	100	319	218	705	155	101	122	32	88	456	113	165	70	19	53	7	110	48	54	30	57
Colorado River: Parker Dam, Ariz.	5	46	4	32	13	98	2	15	13	111	4	35	27	233	1	48	1	44	1	44	2	99	1	26	2	49	1	13	1	19	1	44	1	18
Columbia River: Wenatchee, Wash.	1	18	3	83	5	139	4	89	3	78	2	52	3	76	6	126	7	88	1	67	1	24	2	56	2	61	3	68	2	54	0	11	1	32
Pasco, Wash.	23	738	82	2176	65	2239	60	1674	38	1143	47	1556	48	1279	75	2014	42	1475	90	3716	69	2137	236	7281	62	1834	64	1694	51	1907	47	1313	44	2044
Average [a]	12	37	22	145	30	204	79	150	60	149	27	136	33	199	71	198	67	121	12	104	10	99	59	103	21	69	5	52	11	81	16	54	9	47

[a] Except for Port Wentworth, Ga., and Pasco, Wash.

Table 4. Beta radioactivity in dissolved solids

Station	1961				1962								1963								1964								1965					
	July-Sept		Oct-Dec		Jan-Mar		Apr-June		July-Sept		Oct-Dec		Jan-Mar		Apr-June		July-Sept		Oct-Dec		Jan-Mar		Apr-June		July-Sept		Oct-Dec		Jan-Mar		Apr-June		July-Sept	
	pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/		pCi/	
	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g	liter	g
Connecticut River: Enfield Dam, Conn.	----	----	----	----	----	----	----	----	11	83	17	225	33	333	14	185	21	155	13	147	13	139	9	87	10	57	10	84	7	66	5	66	6	53
Hudson River: Poughkeepsie, N. Y.	3	22	11	74	36	231	14	116	14	75	57	420	21	111	25	184	24	129	22	107	15	69	11	79	18	58	23	41	10	58	8	58	9	36
Potomac River: Washington, D. C.	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	28	120	13	55	9	51	10	53	10	33	8	33	5	37	5	27	7	31
Savannah River: Port Wentworth, Ga.	10	157	34	440	38	608	27	399	45	702	24	417	39	461	38	456	25	258	15	172	20	284	16	205	17	158	11	141	7	140	8	129	8	117
Lake Superior: Duluth, Minn.	2	21	3	43	4	42	6	60	5	51	8	106	6	71	10	68	10	97	6	63	5	56	7	107	5	31	5	60	6	70	3	39	4	43
Mississippi River: St. Paul, Minn.	7	25	39	145	14	53	57	236	36	111	23	81	25	90	76	246	54	158	26	80	19	65	43	138	31	102	23	86	18	70	26	91	21	68
New Orleans, La.	12	46	23	97	26	134	29	125	20	67	26	93	23	97	34	132	30	95	27	77	16	61	17	78	20	62	15	56	11	52	11	53	13	45
Missouri River: Williston, N. Dak.	12	22	19	49	19	44	27	63	25	63	26	46	39	82	47	108	45	93	28	53	19	40	29	63	18	40	18	36	28	48	17	40	16	37
St. Joseph, Mo.	14	27	74	100	37	103	54	144	52	103	29	56	35	81	50	85	32	110	21	40	20	40	84	193	32	60	28	52	23	62	21	52	21	43
Ohio River: Cairo, Ill.	9	40	17	102	30	158	20	91	19	107	19	81	24	124	36	155	21	117	18	90	12	62	18	69	13	51	11	44	7	29	8	40	8	35
Rio Grande: Laredo, Tex.	6	11	29	35	19	27	34	69	28	54	33	37	40	47	61	103	46	73	22	35	19	28	31	59	26	47	14	24	21	51	13	26	16	26
Colorado River: Parker Dam, Ariz.	12	15	27	36	41	50	22	24	23	27	31	41	78	90	26	36	21	27	17	24	18	25	23	31	18	20	17	32	20	25	21	25	23	25
Columbia River: Wenatchee, Wash.	3	24	6	59	9	71	7	55	7	60	9	87	17	151	16	87	13	96	14	136	12	96	8	66	11	74	9	84	6	64	6	57	6	52
Pasco, Wash.	234	1965	738	6695	568	4764	144	1215	282	2304	381	4082	494	4350	374	2810	465	3284	843	7167	655	5678	696	5028	459	3825	667	5910	324	2940	213	1739	251	2203
Average *	8	25	25	80	24	91	27	97	22	73	25	116	32	116	36	124	29	106	19	76	15	61	24	85	18	53	15	53	14	53	12	48	13	41

* Except for Port Wentworth, Ga., and Pasco, Wash.

Table 5. Suspended and dissolved solids

Station	1961				1962								1963								1964								1965					
	July-Sept		Oct-Dec		Jan-Mar		Apr-June		July-Sept		Oct-Dec		Jan-Mar		Apr-June		July-Sept		Oct-Dec		Jan-Mar		Apr-June		July-Sept		Oct-Dec		Jan-Mar		Apr-June		July-Sept	
	mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter		mg/liter	
	S[a]	D[a]	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D	S	D
Connecticut River: Enfield Dam, Conn.	....	....	....	....	....	....	....	....	29	185	36	87	35	99	51	92	38	138	24	90	33	92	41	112	35	172	45	120	32	99	40	61	22	124
Hudson River: Poughkeepsie, N. Y.	45	146	58	153	36	159	47	126	34	188	44	140	43	150	40	140	28	182	29	210	38	239	36	145	47	329	44	612	62	176	37	143	25	257
Potomac River: Washington, D. C.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	38	244	31	241	61	160	47	180	46	307	44	243	149	143	33	171	32	245
Savannah River: Port Wentworth, Ga.	50	70	45	128	50	77	42	74	44	81	39	61	58	96	54	82	40	108	32	220	39	68	70	79	39	118	48	77	33	67	33	61	30	79
Lake Superior: Duluth, Minn.	33	109	35	81	30	88	45	102	34	100	26	70	39	86	45	148	36	100	27	90	33	83	31	102	39	139	32	77	31	80	28	76	26	104
Mississippi River: St. Paul, Minn.	39	312	32	270	35	292	104	304	69	344	41	280	37	275	58	312	45	341	36	321	36	293	60	308	31	321	31	264	28	264	46	283	37	304
New Orleans, La.	80	265	187	242	249	200	307	255	85	312	84	273	163	236	169	261	48	316	27	345	140	266	290	225	95	321	103	265	250	204	297	216	195	297
Missouri River: Williston, N. Dak.	453	514	221	466	147	450	3121	453	919	398	682	559	217	505	135	458	69	507	88	536	77	481	151	482	66	446	154	516	196	606	116	427	79	421
St. Joseph, Mo.	977	506	324	529	548	588	1329	373	987	508	285	521	667	473	1713	587	372	406	141	534	119	504	1866	450	794	540	225	532	749	401	1462	411	950	494
Ohio River: Cairo, Ill.	76	219	190	167	220	194	108	228	33	188	119	234	345	201	91	239	39	184	33	215	203	219	142	261	45	253	128	246	228	237	88	206	31	227
Rio Grande: Laredo, Tex.	993	608	250	619	177	698	295	611	3000	527	811	746	177	852	1263	662	6011	634	707	662	345	681	4049	603	1548	605	264	608	51	625	803	554	535	592
Colorado River: Parker Dam, Ariz.	109	848	132	749	123	818	149	874	119	840	137	766	115	813	79	740	36	781	31	698	26	725	39	736	42	990	44	548	34	775	32	810	33	888
Columbia River: Wenatchee, Wash.	41	133	34	108	36	119	41	135	38	114	38	100	44	114	35	185	58	135	22	103	40	126	35	118	40	186	40	105	29	99	31	115	23	110
Pasco, Wash.	33	127	37	111	31	120	46	139	33	124	36	99	38	116	38	135	31	141	27	128	32	116	36	131	35	161	39	114	35	111	32	115	25	118
Average[b]	285	366	146	338	160	341	555	346	486	323	209	344	171	346	334	347	568	331	100	337	96	322	566	310	236	384	96	345	153	309	251	291	166	339

[a] S—suspended; D—dissolved solids

[b] Except for Port Wentworth, Ga., and Pasco, Wash.

In the second part of the study, all stations of the Federal Water Pollution Control Administration's Water Pollution Surveillance System (WPSS) for which data were available were used for the manual computation of solids quality data. Computations were made for the following three 1-month periods:

1. June 1961—Essentially background levels of gross beta radioactivity were obtained. These low levels are attributed to the weapons testing moratorium then in effect.
2. December 1961—Higher levels of gross beta radioactivity had occurred, due to fallout from the resumption of weapons testing.
3. December 1965—A more recent period was selected to indicate current levels of gross beta radioactivity.

Table 6 presents the results of these computations for all WPPS stations. They are arranged in groups corresponding to the basin-oriented regions of the Federal Water Pollution Control Administration, U.S. Department of the Interior.

Results

Data from tables 1 through 5 are graphically shown as sets of five curves in figure 2. The selected stations for this study are listed in each of the tables.

Interpretation

Figure 2 shows the relative changes in the listed parameters over the stated time period. These parameters are discussed below:

Solids—In figure 2 (A), the average dissolved solids level based on ten to twelve stations is

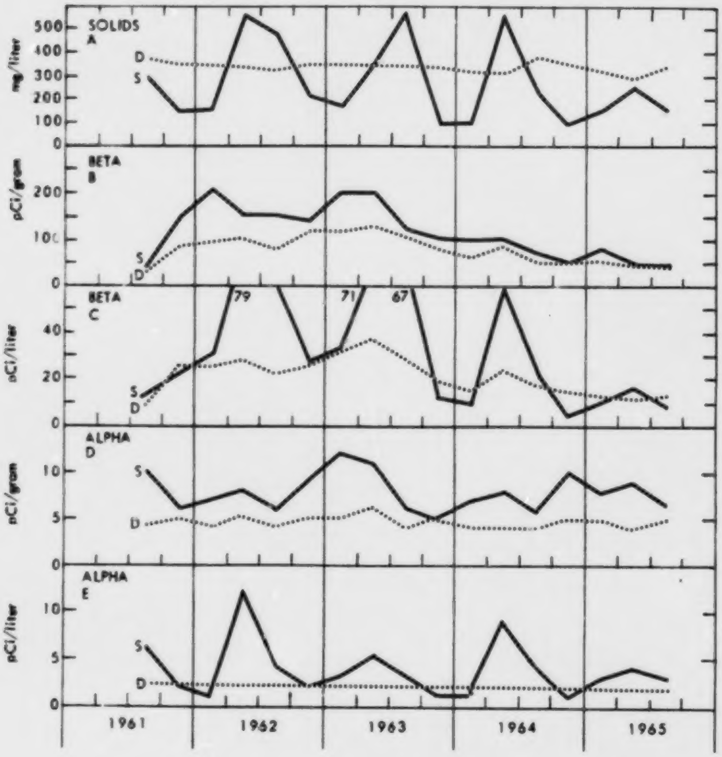

Figure 2. Average gross radioactivity at selected stations of the Water Pollution Surveillance System, 1961–1965

relatively constant over this time period. The suspended solids levels reflect seasonal runoff patterns.

Beta radioactivity—In figure 2 (C), the gross beta radioactivity on dissolved solids as water quality (pCi/liter) shows a drop of approximately 50 percent for calendar years 1964 and 1965 as compared with the period 1961 through 1963. The higher levels during the earlier period are probably a result of fallout transport via water runoff. The suspended solids show clearly the seasonal effects and pattern quite clearly. In figure 2 (B), the beta radioactivity as solids quality on dissolved solids roughly follow the trend of figure 2 (C).

The gross beta radioactivity levels downstream from production reactors are characterized by the discharges of radioactive waste material. Figure 3 shows the gross beta radioactivity on dissolved solids for Pasco, Wash., on the Columbia River. Figure 4 shows the gross beta radioactivity on dissolved solids for Port Wentworth, Ga., on the Savannah River. In these two figures, monthly averages were used in order to show the variability of the levels.

Figure 3 represents the gross beta radioactivity in both water quality and solids quality. The water quality data show less variation than the solids quality data. The discharge of radionuclides superimposed upon the relatively low levels of dissolved solids produces a dramatic increase in the radiological quality of these solids. Figure 3 also shows the average results of solid quality for Wenatchee, Wash. The results reflect the natural level of beta radioactivity upstream from the reactor complex. It is not practical to plot the water quality data on this same scale.

The gross beta radioactivity on dissolved solids for Port Wentworth, Ga., in both water quality and solids quality are shown in figure 4. Again, there are no significant differences in water quality, while the changes in solids quality are dramatic. A reduction in the levels of radioactivity can be noted during and after September 1963.

Alpha radioactivity—In figure 2 (E), the gross alpha radioactivity in the dissolved solids as water quality (pCi/liter) shows a constant level of 2 pCi/liter for the entire period. For the suspended solids, the same parameter shows the effects of the seasonal runoff pattern.

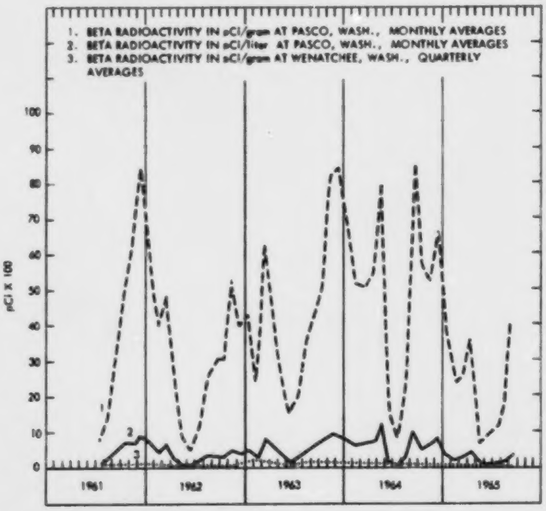

Figure 3. Gross beta radioactivity on dissolved solids in the Columbia River, 1961–1965

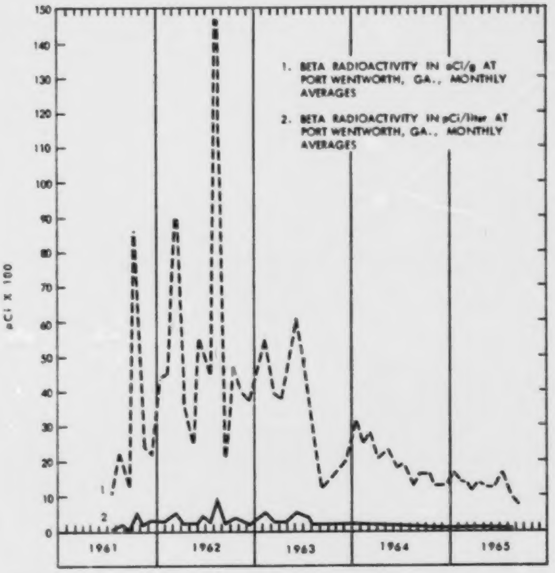

Figure 4. Gross beta radioactivity on dissolved solids in the Savannah River at Port Wentworth, Ga., 1961–1965

Table 6. Gross radioactivity in surface waters

Station and region	River	June 1961				December 1961				December 1965			
		Alpha (pCi/g)		Beta (pCi/g)		Alpha (pCi/g)		Beta (pCi/g)		Alpha (pCi/g)		Beta (pCi/g)	
		D[a]	S[a]	D	S	D	S	D	S	D	S	D	S
NORTHEAST REGION													
Enfield Dam	Connecticut	-----	-----	-----	-----	-----	-----	-----	-----	0	0	65	0
Northfield	Connecticut	0	0	0	0	0	0	188	265	-----	-----	-----	-----
Philadelphia	Delaware	0	0	0	0	0	12	413	1,750	0	26	33	51
Martins Creek	Delaware	0	0	0	0	0	0	296	433	-----	-----	-----	-----
Poughkeepsie	Hudson	0	0	3	39	0	13	118	128	0	0	51	48
Lowell	Merrimack	0	0	0	0	0	0	284	567	-----	-----	-----	-----
Philadelphia	Schuylkill	0	0	0	0	4	8	122	181	-----	-----	-----	-----
MIDDLE ATLANTIC REGION													
Washington, D. C.	Potomac	-----	-----	-----	-----	-----	-----	-----	-----	3	0	5	0
Great Falls	Potomac	0	0	0	0	-----	-----	152	424	-----	-----	-----	-----
Williamsport	Potomac	0	0	0	0	0	0	120	339	-----	-----	-----	-----
Conowingo	Susquehanna	6	0	18	0	0	0	129	316	0	0	15	0
Sayre	Susquehanna	0	0	0	0	0	0	165	306	-----	-----	-----	-----
SOUTHEAST REGION													
Chattahoochee	Apalachicola	0	0	0	0	0	0	43	27	-----	-----	-----	-----
Columbus	Chattahoochee	0	0	0	0	0	0	208	288	-----	-----	-----	-----
Atlanta	Chattahoochee	0	0	11	10	-----	-----	127	223	-----	-----	-----	-----
Kingston	Clinch	-----	-----	-----	-----	-----	-----	-----	-----	2	7	116	284
Clinton	Clinch	-----	-----	-----	-----	-----	-----	-----	-----	0	0	33	0
Rome	Coosa	-----	-----	-----	-----	-----	-----	-----	-----	0	34	48	69
Century	Escambia	0	23	0	0	0	0	171	292	-----	-----	-----	-----
North Augusta	Savannah	0	0	0	0	0	0	145	235	-----	-----	-----	-----
Port Wentworth	Savannah	-----	-----	38	18	0	0	1,395	0	0	0	126	141
Pickwick Landing	Tennessee	-----	-----	-----	-----	0	5	319	270	-----	-----	-----	-----
Bridgeport	Tennessee	0	0	463	0	0	0	468	280	-----	-----	-----	-----
Chattanooga	Tennessee	0	13	339	0	0	20	578	548	0	0	35	83
Columbus	Tombigbee	-----	-----	-----	-----	0	13	406	893	-----	-----	-----	-----
OHIO BASIN REGION													
Pittsburgh	Allegheny	2	0	0	0	0	0	30	16	-----	-----	-----	-----
Cheatham Lock	Cumberland	-----	-----	-----	-----	-----	-----	-----	-----	0	0	58	0
Winfield Dam	Kanawha	0	0	0	0	0	0	89	147	-----	-----	-----	-----
Cincinnati	Little Miami	< 1	6	2	0	0	6	176	555	-----	-----	-----	-----
Cairo	Ohio	12	60	0	0	0	11	102	126	3	0	31	36
Evansville	Ohio	13	11	0	0	0	37	77	281	-----	-----	-----	-----
Louisville	Ohio	0	0	0	0	0	0	296	433	-----	-----	-----	-----
Cincinnati	Ohio	0	10	0	0	0	20	77	207	-----	-----	-----	-----
Huntington	Ohio	0	0	0	0	0	0	83	244	-----	-----	-----	-----
Toronto	Ohio	-----	-----	-----	-----	-----	-----	-----	-----	0	0	35	0
New Harmony	Wabash	-----	-----	-----	-----	-----	-----	-----	-----	5	0	37	40
Pittsburgh	Monongahela	0	0	0	0	2	17	79	157	-----	-----	-----	-----
GREAT LAKES REGION													
Massena	Saint Lawrence	2	6	0	0	0	0	82	140	-----	-----	-----	-----
Buffalo	Lake Erie	0	0	0	0	0	10	52	147	-----	-----	-----	-----
Toledo	Maumee	-----	-----	-----	-----	-----	-----	-----	-----	4	21	55	85
Detroit	Detroit	0	0	0	0	0	0	96	192	-----	-----	-----	-----
Port Huron	Saint Clair	0	0	0	0	0	0	26	69	-----	-----	-----	-----
Milwaukee	Lake Michigan	2	8	0	0	5	0	48	108	-----	-----	-----	-----
Gary	Lake Michigan	0	0	0	0	0	0	67	280	-----	-----	-----	-----
Duluth	Lake Superior	0	0	0	0	0	0	42	92	0	0	49	0
Sault St. Marie	Lake Superior	0	0	0	0	10	0	70	99	-----	-----	-----	-----
Peoria	Illinois	1	7	31	0	0	11	56	271	7	34	24	119
Grafton	Illinois	-----	-----	-----	-----	< 1	1	62	91	6	22	12	67
Cape Girardeau	Mississippi	3	16	0	0	7	0	78	195	-----	-----	-----	-----
East Saint Louis	Mississippi	0	0	3	33	3	0	105	264	8	30	40	91
Burlington	Mississippi	4	10	0	0	0	18	58	109	-----	-----	-----	-----
Dubuque	Mississippi	0	0	0	0	9	0	102	267	-----	-----	-----	-----
Saint Paul	Mississippi	6	23	0	0	4	0	111	629	7	0	53	0
MISSOURI BASIN REGION													
Hardin	Big Horn	-----	-----	-----	-----	-----	-----	-----	-----	13	0	28	28
Sioux Falls	Big Sioux	5	5	0	8	< 1	1	71	151	-----	-----	-----	-----
DeSoto	Kansas	-----	-----	-----	-----	-----	-----	-----	-----	7	0	30	56
Saint Louis	Missouri	11	30	8	28	5	7	103	189	-----	-----	-----	-----
Kansas City	Missouri	8	15	0	18	3	6	50	125	-----	-----	-----	-----
Saint Joseph	Missouri	0	3	0	30	10	0	55	78	13	24	51	79
Omaha	Missouri	8	8	24	14	4	10	55	24	-----	-----	-----	-----
Yankton	Missouri	8	0	16	0	8	13	39	57	-----	-----	-----	-----
Bismarck	Missouri	9	0	7	0	-----	-----	29	4	7	12	43	39
Williston	Missouri	11	26	15	38	-----	-----	39	43	10	0	33	63
Henry	North Platte	-----	-----	-----	-----	34	0	65	162	44	20	68	181
Plattsmouth	Platte	-----	-----	-----	-----	14	3	3	100	16	22	48	75
Grand Forks	North Red	3	0	0	0	-----	-----	-----	-----	4	0	56	0
Baudette	Rainy	-----	-----	-----	-----	-----	-----	-----	-----	0	0	147	79
Int'l. Falls	Rainy	-----	-----	-----	-----	0	0	210	157	-----	-----	-----	-----
Julesburg	South Platte	24	7	31	0	27	15	49	54	26	27	43	107
Sidney	Yellowstone	4	4	8	77	10	14	42	41	7	24	25	24

Table 6. Gross radioactivity in surface waters—continued

Station and region	River	June 1961				December 1961				December 1965			
		Alpha (pCi/g)		Beta (pCi/g)		Alpha (pCi/g)		Beta (pCi/g)		Alpha (pCi/g)		Beta (pCi/g)	
		D	S	D	S	D	S	D	S	D	S	D	S
SOUTH CENTRAL REGION													
Pendleton Ferry	Arkansas	0	3	0	0	4	20	136	259	------	------	------	------
Ponca City	Arkansas	4	16	11	0	0	0	69	231	5	23	7	50
Coolidge	Arkansas	15	0	1	28	13	9	28	44	9	13	20	74
Morgan City	Atchafalaya	------	------	------	------	------	------	------	------	4	18	28	56
New Orleans	Mississippi	3	12	13	17	4	32	154	189	3	0	27	0
New Roads	Mississippi	------	------	------	------	------	------	------	------	6	23	49	114
Delta	Mississippi	9	27	9	3	6	25	118	554	------	------	------	------
West Memphis	Mississippi	4	8	4	22	4	27	130	327	------	------	------	------
Alexandria	Red	8	8	0	0	8	18	108	183	1	22	29	65
Index	Red	0	7	0	0	6	16	111	442	------	------	------	------
Denison	Red	5	0	0	0	------	------	16	37	------	------	------	------
Brownsville	Rio Grande	4	9	0	18	2	6	28	103	------	------	------	------
Laredo	Rio Grande	6	26	0	16	11	0	38	82	7	14	29	61
El Paso	Rio Grande	14	8	<1	0	6	15	25	109	2	0	14	0
Alamosa	Rio Grande	3	0	18	0	7	0	41	100	------	------	------	------
Ruliff	Sabine	0	15	0	7	11	19	427	477	------	------	------	------
SOUTHWEST REGION													
Cedar Hill	Animas	20	14	34	34	25	36	79	199	6	17	28	68
Preston	Bear	------	------	------	------	------	------	------	------	6	0	25	69
Yuma	Colorado	5	3	0	0	< 1	7	14	32	------	------	------	------
Parker Dam	Colorado	11	0	0	62	7	0	31	48	12	0	30	0
Boulder City	Colorado	13	0	1	0	11	3	31	53	------	------	------	------
Page	Colorado	12	49	1	40	14	24	44	98	8	0	39	23
Loma	Colorado	4	24	3	48	1	20	4	176	15	90	34	231
Dutch John	Green	------	------	------	------	------	------	------	------	6	0	35	0
Keno	Klamath	0	0	3	8	0	0	132	625	0	0	52	17
Vernalis	San Joaquin	------	------	------	------	------	------	------	------	5	36	24	36
Shiprock	San Juan	------	------	------	------	18	7	54	35	6	24	32	69
NORTHWEST REGION													
Fairbanks	Chena	------	------	------	------	------	------	------	------	0	0	11	71
Lewiston	Clearwater	------	------	------	------	------	------	------	------	4	0	44	97
Clatskanie	Columbia	0	0	115	145	0	0	825	862	7	0	251	265
Bonneville	Columbia	0	0	215	303	9	0	3,363	843	------	------	------	------
McNary Dam	Columbia	0	0	360	296	7	0	3,527	1,532	------	------	------	------
Pasco	Columbia	0	0	362	195	9	0	8,545	2,945	9	0	950	2,276
Wenatchee	Columbia	0	0	0	0	9	0	66	88	8	0	25	0
Albeni Falls Dam	Pend Oreille	------	------	------	------	------	------	------	------	7	0	35	13
Wawawai	Snake	13	0	38	0	9	0	90	304	11	0	41	71
Payette	Snake	------	------	------	------	------	------	------	------	12	0	31	26
Richland	Yakima	0	6	0	12	9	0	63	261	------	------	------	------

[a] D, dissolved solids.
S, suspended solids.

In figure 2 (D), the alpha radioactivity on the suspended and dissolved solids as solids quality in each instance shows irregular patterns of rise and fall which seem independent of runoff patterns. Where suspended solids are involved, engineering and construction activities in which quantities of fresh earth are exposed to erosion could well account for some of these changes.

Gross radioactivity on individual samples at single stations

The usefulness of solids quality has been demonstrated in reducing the uncertainties that sometimes arise when water quality has been considered without interpretation. During periods of heavy runoff, water quality can vary enormously. Questions may arise as to whether there is radiological contamination. By computing the solids quality, the problem, if there is one, and its magnitude can be determined. In parts of the Southwest, erosion is a significant process in rainfall and may cause very high turbidity in flowing waters or even cause mud flows. Such mud suspensions are received as samples and the analytical results only serve to point up the nature of the samples.

In table 6 no interpretation is offered in regard to radiological values at certain stations or on certain streams or tributaries. Each unusual value may be considered with respect to the *U.S. Public Health Service Drinking Water Standards* (*6*). Radioactivity values as solids quality are useful and necessary as a screening device, after which the levels of specific radionuclides can be determined as the occasion warrants.

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Technical Notes

Survey of Therapeutic X-Ray Installations in Alabama

William T. Willis and *Edward Cowan*[1]

The Bureau of Environmental Health of the Alabama State Department of Public Health has completed a radiological health survey of all known therapeutic X-ray installations within the State. The 20 therapeutic units located in Jefferson County were surveyed independently by the Jefferson County Health Department and brought into full compliance with provisions of the Alabama regulations for control of radiation; these units are excluded from this report.

The survey consisted of a physical inspection of each X-ray therapy unit to determine compliance with all applicable provisions of the Alabama regulations for control of radiation. All of the items required by Alabama regulations are based upon the recommended requirements of the National Committee on Radiation Protection, as published in National Bureau of Standards Handbook 76, and are identical to the suggested State regulations for the control of radiation as prepared by the Council of State Governments. The inspections were performed over a period of 1 year by a technically trained team of one radiation physicist and one registered X-ray technician.

A total of 38 X-ray therapy units was surveyed. Table 1 shows the units by type of therapy and category of use. Almost three-fourths of the X-ray therapy units are used in private medical practice.

Table 1. Number of units surveyed by type therapy and category of use

Type therapy	Category of use	
	Hospital	Private practice
Superficial	4	18
Deep[a]	7	9

[a] "Deep therapy" now called "orthovoltage therapy" in the "Planning Guide for Radiologic Installations," edited by Wendell G. Scott (1966).

A geographical distribution by county shows that two-thirds of the 38 therapy units are located in four counties, and that the remaining units are distributed in eight other counties. Excluding Jefferson County, therapeutic X-ray units are available in twelve of the remaining 66 counties; thus 54 counties have no X-ray therapy units. The distribution of units by county is shown in table 2.

Table 2. Distribution of therapy units by counties

County	Number of units
Montgomery	10
Mobile	6
Etowah	5
Tuscaloosa	3
Chambers	2
Morgan	2
Houston	2
Lauderdale	2
Calhoun	2
Madison	2
Randolph	1
Dallas	1
Total	38

Using the workload value of 4,000 milliampere-minutes/week found in the National Bureau of Standards Handbook 76 as the basis for shielding calculations, the superficial therapy units in Alabama have very low workloads. It can be seen in table 3 that three-fourths of the units have a workload of only one-fourth the 4,000 milliampere-minutes/week used in Handbook 76.

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Table 3. Workloads of superficial therapy units

Milliampere-minutes/week	Number of units
0 to 500	8
500 to 1,000	5
1,000 to 1,500	2
1,500 and above	3
Workload unknown	4

Using the National Bureau of Standards Handbook 76 figure of 40,000 milliampere-minutes/week as the basis for shielding calculations for deep X-ray therapy units, the deep X-ray therapy units in Alabama have relatively lower workloads than the State's superficial therapy units. Table 4 illustrates that the majority of the units have very small workloads; in fact, over one-half of the deep therapy units have a workload less than 3 percent of the National Bureau of Standards Handbook 76 value.

Table 4. Workloads of deep therapy units

Milliampere-minutes/week	Number of units
0 to 1,000	8
1,000 to 2,000	4
2,000 and above	3
Workload unknown	1

All of the therapy units were found to be in full compliance with 9 of the 14 required items. Almost all of the required items were related to physical aspects of the therapy units. The specific items inspected and found to be in compliance were: (1) therapeutic tube housing, (2) filters secure in place, (3) tube alignment, (4) tube housing stability, (5) timer provided, (6) timer terminates exposure, (7) tube "on" indicator, (8) adequate operator protection, and (9) patient observation.

Eighty-four percent of the 38 therapy units were found to be in noncompliance with one or more of the remaining five required items. These required items are interlocks provided (63 percent in noncompliance), interlocks functioning (8 percent in noncompliance), shielding adequate (11 per cent in noncompliance), radiation caution signs properly displayed (84 percent in noncompliance) and film badges provided (37 percent in noncompliance).

All X-ray therapy units should be provided with interlocks so that when any door of the treatment room is opened, either the unit shuts off automatically, or the radiation level within the room is reduced to a level of not more than 2 milliroentgens per hour. It is important to note that only units operating at 60 kVp and below are excepted from this requirement. This means that superficial therapy units operating above 60 kVp are governed by this requirement as well as deep therapy units. Several physicians thought that the installation of interlocks for superficial units would serve no useful purpose. Explanations given for this position were: (1) normally, the physician personally observes the patient and controls the area during treatment; (2) any interruption of treatment which necessitates entering the treatment room can be performed easily by turning off the unit from the control panel; (3) superficial units operate at low energies, generally from 60 to 70 kilovolts; and (4) most treatments are made with small diameter collimators. Probably as a reflection of this attitude toward interlocks, 17 superficial units were in noncompliance while only 7 deep units were found to be in noncompliance with this item.

Interlocks should be functioning properly in order to accomplish their purpose. Fourteen installations had interlocks and only one of these was found to be in noncompliance with this item.

Shielding adequacy requires that all wall, floor, and ceiling areas that can be struck by the primary beam, plus a border of 1 foot, be provided with primary protective barriers. All other wall, floor, and ceiling areas should be provided with secondary barriers. Both primary and secondary protective barriers must be sufficient to reduce the incident radiation to acceptable levels in unrestricted areas. Direct radiation measurements were taken during the survey to determine the adequacy of shielding. Using these actual radiation measurements, shielding computations determined that only four of the 38 units were at installations with insufficient shielding.

Each X-ray installation should be conspicuously posted with a warning sign which cautions that the treatment area is a radiation area. Eighty-four percent of all therapy units were found to be in noncompliance with this requirement. The item presents little difficulty as it can be corrected more easily than any of the other items of noncompliance.

Thirty-seven percent of all therapy units were operated by persons who did not wear a film badge, and consequently could not determine their occupational radiation exposure. Every person who reasonably could be expected to receive an exposure of 25 milliroentgens per week should wear a personnel monitoring device. Fortunately, this requirement is relatively easy to correct.

Subsequent to the inspection of each therapy unit a letter from the State Health Officer advised all installations of the inspection results. If an installation was found to be in noncompliance the letter pointed out the deficiency for each item of noncompliance and made recommendations for compliance. When the items of noncompliance had been corrected, the State Department of Public Health was informed and a reinspection was conducted to verify each correction. Initially 11 therapy units were in full compliance and 12 months later 36 of 38 units (95 percent) were in full compliance with the regulations. The high degree of compliance occurred because the physicians voluntarily cooperated with the requests of the health department. Enforcement aspects of the regulations were deliberately deemphasized.

Summary and discussion

All known X-ray therapy units in the State have been inspected for compliance with Alabama regulations for control of radiation. A total of 38 therapy units were inspected. During 1 year, the number of therapy units in full compliance was increased from 11 to 36. Only four of the 38 therapy machines were located in installations with insufficient shielding. The extremely low work load of most therapy units is largely responsible for the high degree of compliance with the requirement of shielding. The requirement for interlocks for superficial therapy units generated considerable constructive criticism concerning the need for this regulation. The reluctance of physicians to accept the requirement of interlocks for superficial therapy units as necessary or useful indicates that the rationale for this item should be reevaluated. With the exception of the difficulties regarding the requirement of interlocks for superficial units, the inspection of all X-ray therapy installations was well received by the physicians. Success of the survey is attributed largely to physician cooperation rather than regulatory enforcement.

Radium Survey in Alabama

William T. Willis and *Edward Cowan*[1]

Incidents have occurred in several States involving ruptured radium sources at hospitals, physicians' offices, and in industry. Preventive measures to avoid a ruptured source are compelling when public health and other consequences of a rupture incident are considered. Decontamination costs are expensive; for example, one industry spent $250,000 for decontamination following the rupture of a radium capsule. A source, however, need not rupture to allow the escape of radon and its daughter products. Small quantities of radon gas frequently leak from the source as a result of microscopic fissures. The leaking radon gas results in contamination, but perhaps more importantly, it serves as a warning sign that the source encapsulation has deteriorated, portending possible trouble of a more serious nature; namely gross rupture. The purpose of a radium survey is to detect leaking sources before a serious rupture occurs, and to detect contamination in order that contaminated areas are decontaminated before serious problems develop.

Radium sources in Alabama have never been licensed, inspected, or subjected to State or Federal regulatory requirements prior to 1965. Health departments in other States have found significant numbers of facilities with leaking radium sources and contaminated equipment (*1*).

During 1964, the Jefferson County Health Department surveyed all radium sources in Jefferson County to determine the kind and degree of existing associated radiation hazards. Among conditions and practices found to be inadequate, leaking radium sources were numerous. Four of the ten facilities surveyed had one or more leaking radium sources and three of the four were significantly contaminated. Physicians and representatives of industry viewed the survey as a service and showed their acceptance by responding favorably to the Jefferson County Health Department recommendations (*1*).

The Alabama State Department of Public Health was encouraged by the accomplishments of the Jefferson County survey and conducted a similar survey for all radium users in the remaining counties of the State. The survey had three objectives:

1. to test all know sources of radium for leakage,
2. to determine the presence of contamination, and
3. to train staff personnel in conducting inspections of radioactive materials.

Thirty-seven facilities were registered as having radium on their premises. The State Health Officer wrote each facility to explain the nature and purpose of the survey emphasizing that participation in the survey and compliance with Department recommendations would be entirely voluntary. Post cards were

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enclosed to notify the Department of intended participation. Response to letters exceeded expectations:

Letters to radium facilities	37
Response from facilities in 1 month	37
Wanted to participate	28
Did not want to participate	2
Did not possess radium	7

The two nonparticipating facilities asked to be included after a second letter further explained the intent of the survey.

Bureau of Environmental Health personnel began the survey in April 1965, by making appointments with the users for all visits. The "jar-test method," which enables detection of alpha particles emitted by radon daughters, was used for leak testing the sources (2). A radium source is placed into a small glass jar and sealed with a screw-on cap. After the source has remained in the closed jar for 24 hours, the jar lid is removed. The jar lid is turned over and monitored with a gas-flow proportional counter. The relative absence of alpha particles indicates that the source is not leaking and is not contaminated by a source that is leaking. The survey is concluded if the source is found not to be leaking. If the source is found to be leaking or contaminated, additional monitoring is performed on the storage container, equipment, and the premises to determine the extent of contamination. At the present time there are no uniform standards that differentiate between a leaking and nonleaking source. The sensitivity of the testing system would justify the selection of approximately 100 to 1,000 counts per minute as a standard. In the absence of a recommended uniform standard, 1,000 alpha-particle counts per minute was chosen to indicate a leaking source for this survey.

Of the 30 users in Alabama, 9 were hospitals, 18 private physicians, and 3 industrial users. Thus, radium is used in Alabama primarily in the field of medicine and by private physicians. The 30 facilities possessed a total of 2,638 milligrams of radium of which 495 milligrams were either leaking or contaminated. Thirteen of the 30 facilities had one or more leaking sources and all but one of these sources were possessed by private physicians.

A commercial firm had performed leak tests of radium sources at 7 facilities within the last 2 years. If routine leak testing is of value, one would expect to find fewer leaking sources among those previously leak tested. Of the 7 facilities which had undergone testing within the past 2 years, only one was found to have leaking sources, whereas of the 23 facilities which had not undergone testing previously, 12 were found to have leaking sources. This points out the importance of periodic leak testing.

Radium sources are either privately owned or rented. A high percentage of owned sources had never been leak tested; therefore one would expect to find more leaking sources among those privately owned than among those rented. Of the 20 sources which were privately owned, 11 were found to be leaking, whereas only 2 of the 11 rented sources were leaking.

By using 1,000 alpha-particle counts per minute as the minimum standard to indicate a leaking source, it was thought that some of the test results might group around the standard creating borderline situations. This was not the case. Table 1 shows that there were no marginally leaking sources and that the largest percent of leaking sources were, in fact, heavily leaking. Wherever a leaking radium source was found, contamination of the immediate area was also found. Oddly enough, contamination was also present at 5 facilities which did not possess a leaking source. This finding supports the proposition that sources can leak intermittently. It is interesting to note that generally, the contamination was confined quite closely to the area of the storage container and in no case was it wide-spread. This fact minimized the contamination hazard and made decontamination easy.

Following the survey, a letter was sent to each facility stating the survey findings and, when applicable, making recommendations concerning leaking sources and contaminated areas. Decontamination was performed at each facility where contamination was found. Decontamination procedures in these cases involved only a simple process of washing and scrubbing, since no case was found where contamination was serious enough to justify the procurement of decontamination services from a commercial firm. Leaking sources at all but one facility were either disposed of through an arrangement with the U.S. Public Health Service or re-encapsulated. As a result of the survey 212 milligrams of radium were disposed of by private physicians and 45 milligrams by hospitals. An additional 105 milligrams was re-encapsulated for facilities that did not wish to dispose of the radium.

Table 1. Magnitude of radium leaking sources

Number of facilities	Alpha particle radioactivity range (counts per minute)
2	1,000- 25,000
4	25,000- 50,000
0	50,000- 75,000
7	75,000-100,000

Summary

Of the 30 facilities using radium in Alabama, 13 had one or more leaking sources. Twelve facilities fully complied with recommendations for disposal or re-encapsulation. Recommendations were made for six facilities to decontaminate, and all six complied. Only one radium user had not complied with our recommendations, and this is the result of indecision over what action to take rather than a refusal to act. The reception given the survey team by physicians and the voluntary compliance by physicians with recommendations of the Bureau of Environmental Health was excellent.

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Data

SECTION I. MILK AND FOOD

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Federal and State agencies are involved in efforts to monitor continuously the dietary intake of radionuclides. The most direct measure of radionuclide intake would be obtained through radioanalysis of the total diet. Difficulties in obtaining specific dietary data impede this approach. An alternate method entails the use of indicator foods to arrive at an estimate of the total dietary radionuclide intake.

Fresh milk is one such indicator food. It is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides which appear in the diet. It also is one of the major sources of dietary intake for the short-lived radionuclides. For these reasons, fresh milk is the single food item most often used in estimating the intake of selected radionuclides by the general population and/or specific population groups. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of fresh milk.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (*1-3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission on Radiological Protection (*5,6*).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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National and International Milk Surveillance

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide levels in milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in milk, HASL	July–December 1966	September 1967

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1. Pasteurized Milk Network
September 1967

National Center for Radiological Health
and *National Center for Urban and*
Industrial Health, PHS

The Public Health Service's pasteurized milk surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for large scale programs. Experience derived from this earlier network led to the activation of the Pasteurized Milk Network (PMN) with stations selected to provide continuing nationwide measurement of radionuclide levels in pasteurized milk through sampling of major milk production and consumption areas and to provide information on concentration levels and trends from which local, State, and Federal agencies can determine the need for further investigation and/or cor-

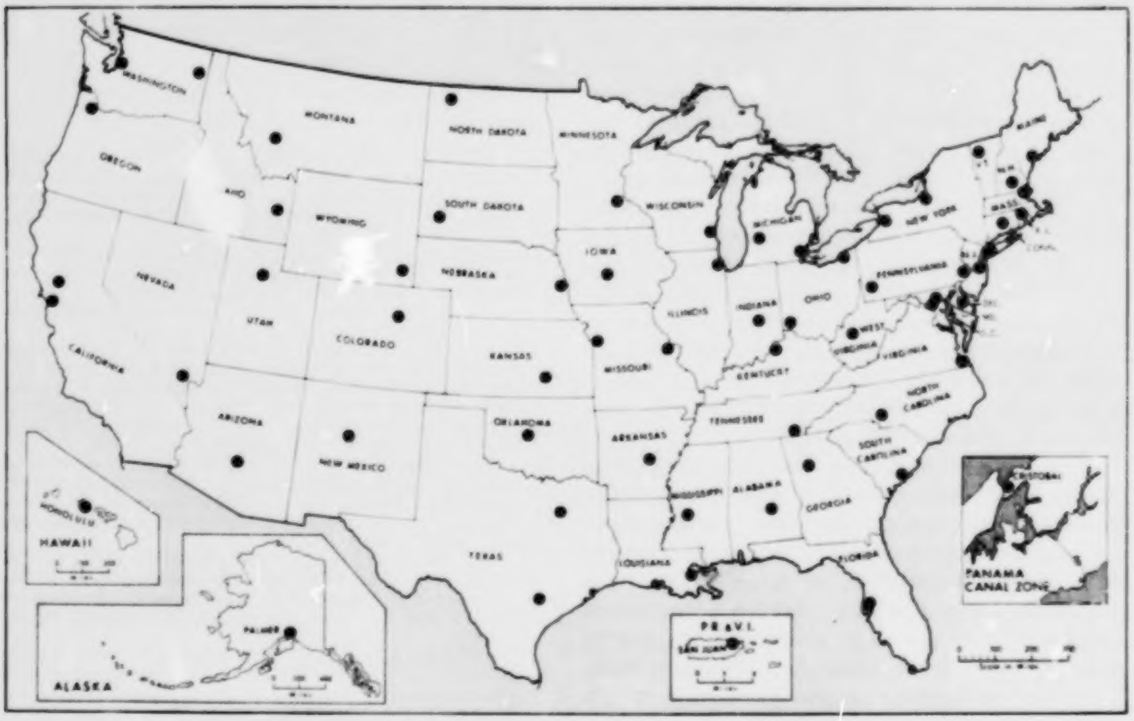

Figure 1. Pasteurized Milk Network sampling locations

rective action for the protection of public health. The present network consists of 63 stations with at least one in every State, the Canal Zone, Puerto Rico, and Washington, D.C. (figure 1).

Sampling procedures

Samples are collected with the cooperation of State and local milk sanitation authorities. According to established procedures, the sample at each station is a composite of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations, the composited sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as possible under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week, except for brief periods of known or suspected increased fallout when samples were taken twice a week.

After compositing, samples are preserved with formaldehyde and sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern (NERHL) Radiological Health Laboratories for analysis.

Analytical procedures

Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma-ray scintillation spectrometry. After the weekly samples are gamma scanned, samples from two consecutive weeks are composited and analyzed radiochemically to determine strontium-89 and strontium-90. With all such measurements, there is an inherent statistical variation. For the low radionuclide levels usually observed in milk and other environmental samples, this variation on a percentage basis is relatively high. It depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma-ray spectrometry and 30 to 50 minutes for beta-particle determinations are used. Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. The minimum detectable concentration is defined here as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable concentrations in pCi/liter are: strontium-89, 5; strontium-90, 2; cesium-137, 10; barium-140, 10; and iodine-131, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

Gamma-ray analyses are made within 3 to 6 days after sample collection and radiochemical analysis results are normally available 4 to 5 weeks after the weekly samples are received by the laboratories. Short-lived radionuclide concentrations are corrected back to the date of collection.

Table 1. Analytical errors associated with determinations of radionuclide concentrations in milk

Nuclide	Concentration (pCi/liter)	Error [a] (pCi/liter)	Concentration (pCi/liter)	Error [a] (percent of concentration)
Strontium-89	< 50	5	≥ 50	10
Strontium-90	< 20	2	≥ 20	10
Iodine-131	<100	10	≥ 100	10
Cesium-137	<100	10	≥ 100	10
Barium-140	<100	10	≥ 100	10

[a] Two standard deviations.

Data presentation

The results for September 1967, and the third quarter of 1967, are presented in figure 2. If radionuclide levels were below minimum detectable concentrations, averages were calculated using one-half the minimum detectable values; however, for iodine-131 and barium-140, zero was used for averaging purposes when concentrations were below minimum detectable levels. Values for iodine-131 and barium-140 were below minimum detectable concentrations during the period covered in this report. Values for strontium-89, except for Wichita, Kans. (5 pCi/liter), were also below minimum detectable concentrations. Results for these three radionuclides have not been included in table 2.

Table 2. Average concentrations of radionuclides in pasteurized milk for the third quarter 1967 and September 1967

Sampling location		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)	
		Third quarter 1967	Sept 1967	Third quarter 1967	Sept 1967
Ala:	Montgomery	9	11	15	15
Alaska:	Palmer	6	6	25	25
Ariz:	Phoenix	2	1	< 5	< 5
Ark:	Little Rock	24	23	20	20
Calif:	Sacramento	4	3	5	10
	San Francisco	3	2	5	5
C. Z:	Cristobal	4	3	15	15
Colo:	Denver	7	6	10	10
Conn:	Hartford	10	9	20	15
Del:	Wilmington	11	11	15	10
D. C:	Washington	10	10	10	10
Fla:	Tampa	8	7	80	80
Ga:	Atlanta	16	14	25	25
Hawaii:	Honolulu	4	3	10	10
Idaho:	Idaho Falls	6	5	10	10
Ill:	Chicago	8	8	15	15
Ind:	Indianapolis	8	6	10	10
Iowa:	Des Moines	8	6	10	5
Kans:	Wichita	8	6	10	10
Ky:	Louisville	13	12	10	10
La:	New Orleans	24	24	30	25
Maine:	Portland	13	12	35	30
Md:	Baltimore	11	11	10	10
Mass:	Boston	13	12	30	25
Mich:	Detroit	9	8	15	15
	Grand Rapid	10	8	15	15
Minn:	Minneapolis	13	12	15	15
Miss:	Jackson	19	18	15	20
Mo:	Kansas City	11	9	5	< 5
	St. Louis	10	11	5	10
Mont:	Helena	6	6	10	15
Nebr:	Omaha	10	9	10	5
Nev:	Las Vegas	2	2	5	< 5
N. H:	Manchester	15	13	45	40
N. J:	Trenton	10	10	10	10
N. Mex:	Albuquerque	3	3	5	< 5
N. Y:	Buffalo	8	7	15	15
	New York City	11	11	15	10
	Syracuse	9	9	15	20
N. C:	Charlotte	17	16	20	15
N. Dak:	Minot	11	10	10	10
Ohio:	Cincinnati	9	7	10	10
	Cleveland	10	8	15	10
Okla:	Oklahoma City	11	12	10	5
Ore:	Portland	8	8	20	15
Pa:	Philadelphia	10	9	10	10
	Pittsburgh	13	10	15	15
P. R:	San Juan	5	4	15	15
R. I:	Providence	12	12	30	25
S. C:	Charleston	16	16	35	30
S. Dak:	Rapid City	13	9	15	15
Tenn:	Chattanooga	17	16	20	15
	Memphis	14	14	10	5
Tex:	Austin	3	3	10	< 5
	Dallas	10	7	10	15
Utah:	Salt Lake City	6	4	15	15
Vt:	Burlington	11	9	20	15
Va:	Norfolk	13	12	15	10
Wash:	Seattle	10	10	35	30
	Spokane	9	8	15	10
W. Va:	Charleston	12	9	10	10
Wis:	Milwaukee	7	6	15	15
Wyo:	Laramie	5	6	10	10
Network average		9.9	9.1	15	15

For comparative purposes, distributions of strontium-90 and cesium-137 are presented in tables 3 and 4 for September 1966, and April through September 1967. The average strontium-90 concentrations in pasteurized milk from selected cities are presented in figure 2.

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Table 3. Frequency distribution, strontium-90 concentrations at PMN stations, September 1966 and April–September 1967

Strontium-90 (pCi/liter)	Number of stations *						
	1966	1967					
	Sept	April	May	June	July	Aug	Sept
Under 10	21(33)	25(40)	25(40)	27(43)	25(40)	35(55)	37(59)
10-19	37(59)	34(54)	35(55)	34(54)	35(55)	26(42)	24(38)
20-29	5(8)	4(6)	3(5)	2(3)	3(5)	2(3)	2(3)
30-39	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)

* Percentage of stations shown in parentheses.

Table 4. Frequency distribution, cesium-137 concentrations at PMN stations, September 1966 and April–September 1967

Cesium-137 (pCi/liter)	Number of stations *						
	1966	1967					
	Sept	April	May	June	July	Aug	Sept
Under 50	61(97)	62(98)	61(97)	61(97)	61(97)	61(97)	62(98)
50-99	1(1.5)	1(2)	2(3)	2(3)	2(3)	2(3)	1(2)
100-149	1(1.5)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)

* Percentage of stations shown in parentheses.

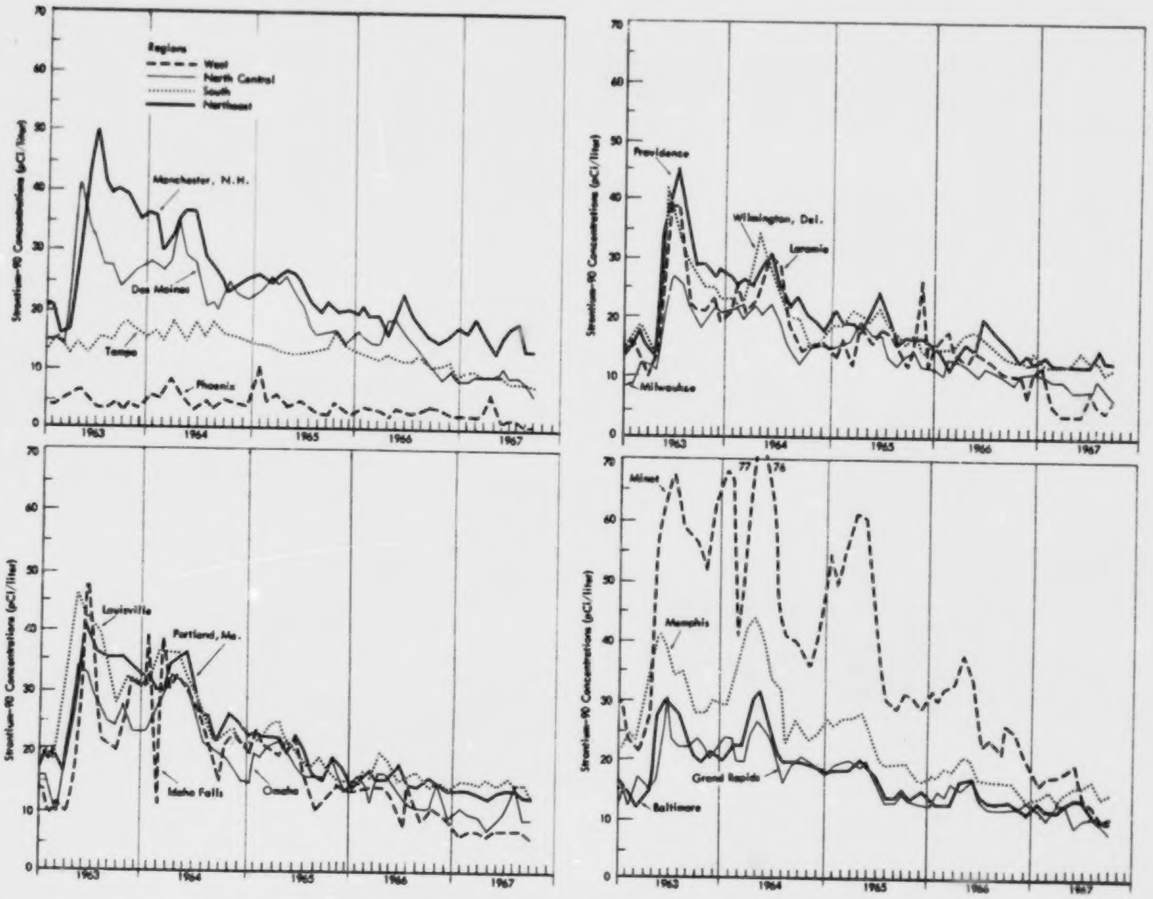

Figure 2. Strontium-90 concentrations in pasteurized milk, 1961–September 1967

2. Canadian Milk Network
September 1967[1]

Radiation Protection Division
Department of National Health and Welfare

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the December 1966 issue of *Radiological Health Data and Reports* (*2*).

The September 1967 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 5. Iodine–131 and strontium–89 concentrations were below minimum detectable levels.

Table 5. Stable elements and radionuclides in Canadian whole milk, September 1967

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.07	1.3	9.5	19
Edmonton	1.13	1.4	5.3	28
Ft. William	1.09	1.5	13.9	30
Fredericton	1.10	1.4	17.8	30
Halifax	1.14	1.4	14.5	27
Montreal	1.09	1.4	8.8	18
Ottawa	1.12	1.4	6.6	18
Quebec	1.12	1.4	14.1	30
Regina	1.12	1.4	7.9	17
St. John's, Nfld	1.09	1.5	25.5	53
Saskatoon	1.10	1.4	8.0	14
Sault Ste. Marie	1.09	1.5	13.6	29
Toronto	1.13	1.4	5.9	16
Vancouver	1.20	1.4	15.0	54
Windsor	1.12	1.4	5.4	15
Winnipeg	1.10	1.5	5.4	25
Average	1.11	1.4	11.1	26

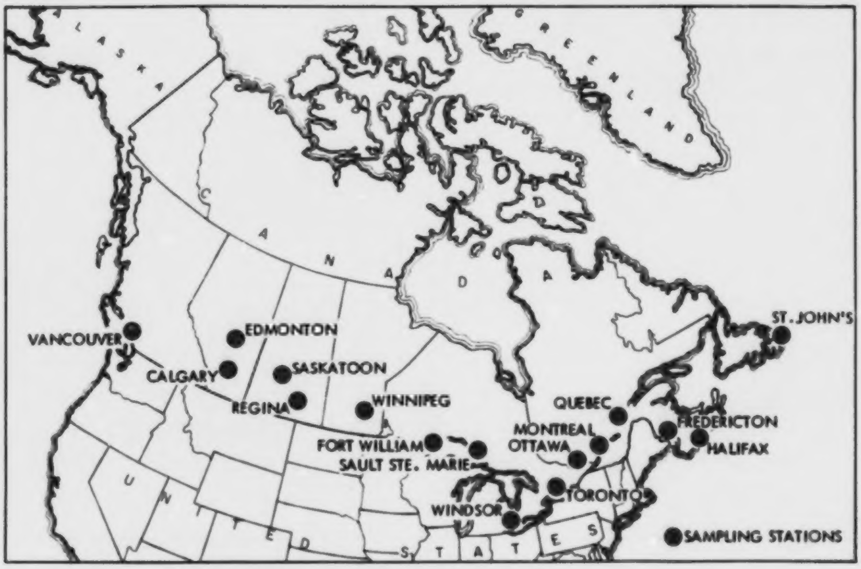

Figure 3. Canadian milk sampling stations

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[1] Prepared from November 1967 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Pan American Milk Sampling Program September 1967

Pan American Health Organization and *U.S. Public Health Service*

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between agencies, air and milk sampling activities are conducted by a number of PAHO-member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (*3*).

Table 6 presents stable potassium, strontium-90, cesium-137, and barium-140 monthly average concentrations for September 1967.

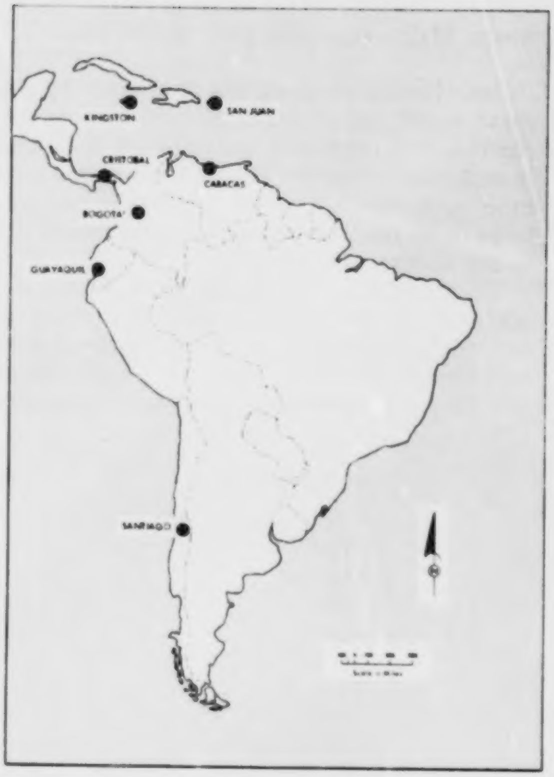

Figure 4. Pan American Milk Sampling Program locations

Table 6. Stable element and radionuclide concentrations in PAHO milk[a] September 1967

Sampling stations		Number of samples	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)	Barium-140 (pCi/liter)
Colombia:	Bogota	1	1.3	1	< 5	<10
Ecuador:	Guayaquil	1	1.6	< 1	10	<10
Jamaica:	Montego Bay	1	1.4	12	365	10
Venezuela:	Caracas	[b]1	1.5	2	10	<10
		1	1.5	3	< 5	15
Canal Zone:	Cristobal[c]	4	1.5	3	16	<10
Puerto Rico:	San Juan[c]	4	1.6	4	14	<10

[a] Strontium-89 was less than 5 pCi/liter and iodine-131 was less than 10 pCi/liter for all samples.
[b] August 1967 data. Sample delayed in transit.
[c] For comparison purposes, the radionuclide concentrations from the Pasteurized Milk Network at Cristobal, Canal Zone, and San Juan, Puerto Rico are presented.

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(*2*) DEPARTMENT OF NATIONAL HEALTH AND WELFARE, RADIATION PROTECTION DIVISION. Canadian milk network, August 1966. Radiol Health Data Rep 7:702–703 (December 1966).

(*3*) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1966. Radiol Health Data Rep 7:704–705 (December 1966).

28

State Milk Surveillance Activities

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States now have comprehensive environmentalal surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

Figure 1 shows the States which report milk surveillance activities in *Radiological Health Data and Reports*. States having programs appearing in this issue are highlighted in the figure. The following is a summary of previously covered State programs, their reporting periods, and issue of appearance.

State milk network	Period reported	Last presented
California	April–June 1967	December 1967
Connecticut	April–June 1967	November 1967
Indiana	April–June 1967	November 1967
Iowa	April–June 1967	November 1967
Michigan	April–June 1967	November 1967
Minnesota	April–June 1967	November 1967
New York	April–June 1967	November 1967
Oregon	April–June 1967	December 1967
Pennsylvania	April–June 1967	November 1967
Washington	April–June 1967	December 1967

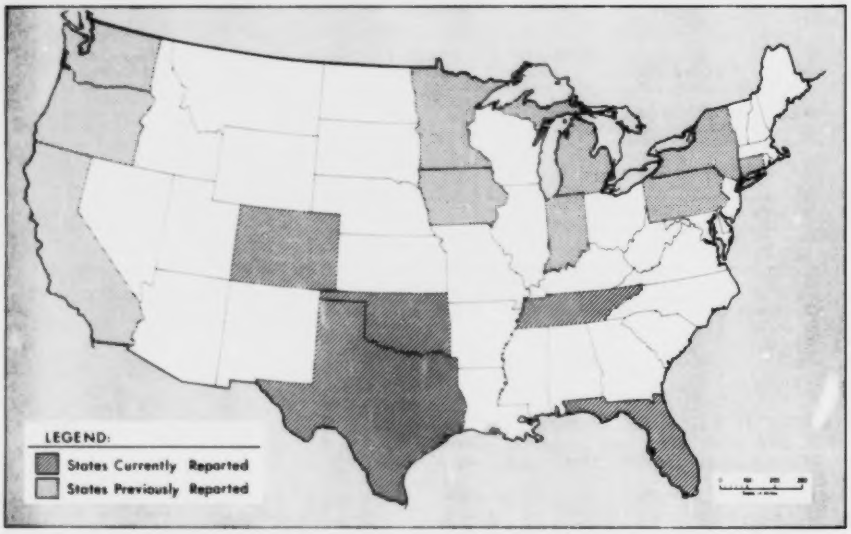

Figure 1. Reported State milk programs

1. Colorado Milk Network
July–September 1967

Occupational and Radiological Health Division
Colorado State Department of Public Health

The Radiological Health Division of the Colorado State Department of Public Health initiated radiological analysis of milk in January 1962. Initially, the Denver City and County Health Department collected a weekly composite milk sample from the major producers in the Denver area for the State, as it had for the Public Health Service since March 1960.

In August 1962, the State expanded its program to include the routine sampling of raw milk from the four major milk producing areas supplying the State: northeastern, southeastern, western Colorado and eastern Utah. Areas of the State presently sampled are western, south central, northeastern, southeastern and eastern Colorado (including northwestern Kansas). Colorado milkshed areas are shown in figure 2.

Analyses are performed for iodine–131, barium–140, cesium–137, and potassium by gamma-ray spectroscopy. The measurement system previously reported (*1*) has been adapted to utilize a 4- by 5-inch NaI crystal shielded by a lead-lined bank safe.

Minimum detectable amounts at the 2 standard deviation counting error equivalent are: 10 pCi/liter for iodine–131 and cesium–137; 15 pCi/liter for barium-lanthanum–140; and 0.2 g/liter for potassium.

Table 1 gives results of the measurement of radionuclides in milk collected from July through September 1967. Barium-lanthanum–140 was not detected during this period.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1967	July 1967
April–June 1967	October 1967

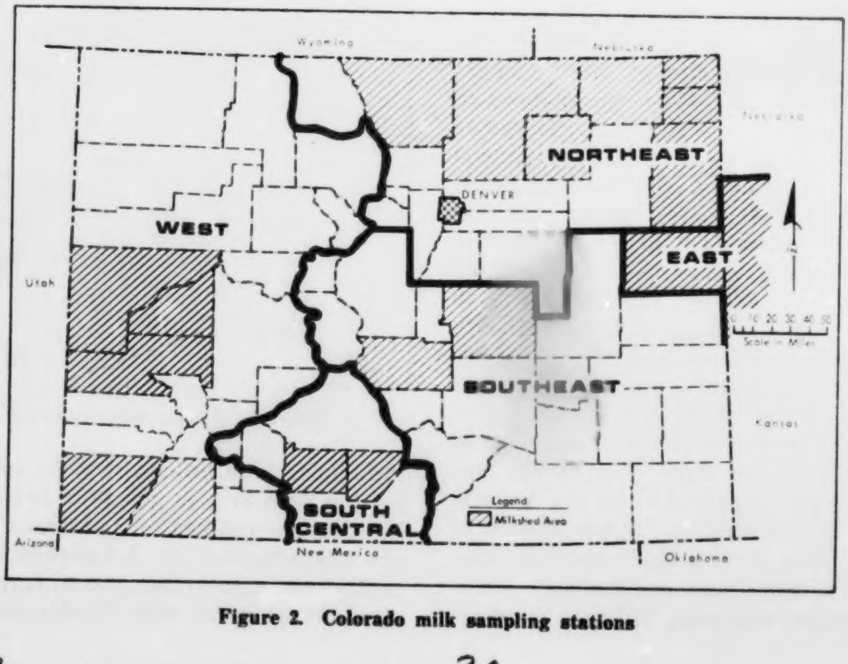

Figure 2. Colorado milk sampling stations

Table 1. Radionuclides in Colorado milk, July–September 1967

Date of sampling	Area sampled [a]	Number of samples analyzed	Number of samples containing detectable radionuclides [b]	Concentration of detectable radionuclides		
				(pCi/liter)		(g/liter)
				Iodine-131	Cesium-137	Potassium
July 1	NE	1	0	ND	ND	1.6
1	NE	1	1	12	36	1.5
1	NE	1	1	ND	32	1.4
July 28	SE	1	0	ND	ND	1.6
August 27	SE	1	1	ND	18	1.7
September 19	SE	1	0	ND	ND	1.4
27	SE	1	1	ND	18	1.7
August 19	SC	1	0	ND	ND	1.4
26	SC	1	0	ND	ND	1.7
September 26	SC	1	0	ND	ND	1.7
July 20	W	1	1	ND	16	1.4
August 10	W	1	1	20	51	1.9
10	W	1	0	ND	ND	1.2
16	W	1	1	24	ND	1.4

[a] NE—Northeastern Colorado
SE—Southeastern Colorado
SC—South Central Colorado
W—Western Colorado

[b] Minimum detectable activity is taken as equal to or greater than the 2-standard counting error equivalent and for the two radionuclides given is 10 pCi/liter.

ND, nondetectable.

2. Florida Milk Network July–September 1967

Division of Radiological Health
Florida State Board of Health

The Florida State Board of Health began sampling raw milk for iodine-131 analysis in two major areas of the State in November 1962. The program has since been expanded to include the analysis of milk for strontium-89, strontium-90, cesium-137, barium-140 and potassium, in addition to iodine-131. Monthly samples are taken from randomly selected farms in each of the six regions shown in figure 3. A regional State Board of Health Laboratory is located in each of the six regions. Each laboratory prepares a monthly composite milk sample for its region by combining samples from 10 percent of the dairy farms selected at random. These composite samples are then sent to the State Radiological Health Laboratory in Orlando for analysis. In the interest of maintaining an active standby capability, samples are also collected and analyzed for iodine-131 on a monthly basis using the resin cartridge technique. Milk produced in the counties comprising each area is generally processed, marketed, and consumed in that area. These areas are characterized by differences in dairying practices related to the gradual transition from small farms in the west Florida region, where

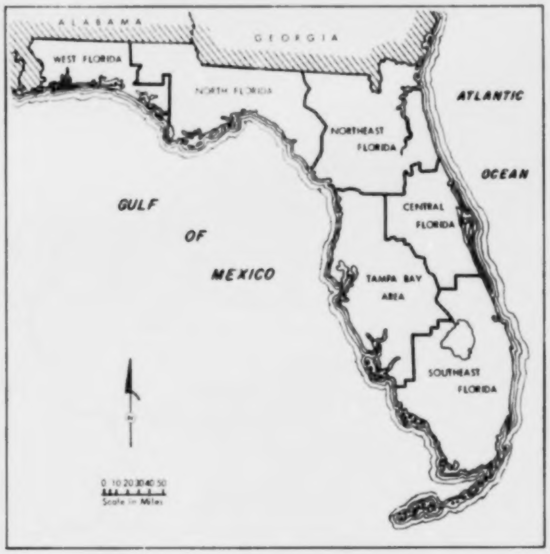

Figure 3. Florida milk sampling areas

Table 2. Stable element and radionuclide concentrations in Florida raw milk, July–September 1967

Sampling location	Strontium-90 (pCi/liter)			Iodine-131 (pCi/liter)			Cesium-137 (pCi/liter)			Barium-140 (pCi/liter)			Potassium (g/liter)		
	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept
Western	20	17	18	<20	<20	<20	31	23	35	ND	32	ND	1.6	1.5	1.5
Northern	23	20	19	<20	<20	<20	37	56	33	ND	24	23	1.6	1.5	1.5
Northeastern	13	13	NA	<20	<20	<20	89	193	122	ND	39	ND	1.6	1.4	1.4
Central	9	21	NA	<20	29	<20	77	157	84	ND	25	ND	1.3	1.7	1.3
Tampa Bay Area	10	10	10	<20	<20	<20	85	125	106	ND	ND	29	1.4	1.4	1.5
Southeastern	9	8	10	<20	<20	<20	113	121	123	30	27	ND	1.4	1.6	1.5
Average	14	15	14	<20	<20	<20	72	113	84	5	25	9	1.5	1.5	1.4

ND, nondetectable.
NA, no analysis

locally grown feeds are used, to larger farms in the southern areas, where different types of grass and predominately purchased feeds are used.

Strontium–89 and strontium–90 are determined by the ion exchange method developed by Porter *et al.* (*2*). Iodine–131, cesium–137, barium–140 and potassium are determined by gamma-ray spectrometry (*3*).

Radionuclide concentration levels for July through September 1967, are presented in table 2. Strontium–89 analyses has been discontinued since 1965 due to extremely low levels.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
April–June 1966	October 1966
January–June 1967 and summary for 1966	October 1967

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3. Oklahoma Milk Network
July–September 1967

Oklahoma State Department of Health [1]

On March 15, 1965, the Radiological Health Section of the Oklahoma State Department of Health initiated a program of analysis for iodine–131 in the milk produced in the State of Oklahoma. On March 7, 1966, analysis for cesium–137 was added to the program.

The location of the sampling stations and the extent of their associated milksheds are shown in figure 4. Of the ten milksheds in the State of Oklahoma, five were chosen as sampling stations (Oklahoma City, Enid, Tulsa, Lawton, and Ardmore) on the basis of their size and location. A major criterion in the selection of a milkshed for sampling was the degree of overlap with other milksheds being sampled. This overlap assists in locating small areas of production where the concentration of radioactivity might be abnormally high.

The sampling stations are located in the laboratory of a major milk-processing plant in each milkshed. While the milkshed for a particular processing plant may not coincide exactly with that shown in figure 4, the coincidence is satisfactory for surveillance purposes.

Analytical method

The method of analysis is similar to that recently published by the U.S. Public Health Service (*4*) but was developed independently by the Oklahoma State Health Department's Radiological Health Laboratory. Details of the procedure used were summarized earlier (*5*).

Results and discussion

Due to instrumental difficulties, only the samples collected on September 1 were analyzed. The concentrations of iodine–131 found in Oklahoma milk were less than the minimum detectable concentration of 3 pCi/liter. Cesium–137 concentrations were <10 pCi/liter for the Oklahoma City, Tulsa and Ardmore samples and 13 pCi/liter for the Enid and Lawton samples.

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[1] Acknowledgment is accorded to the staff of the Radiological Health Section under the direction of Mr. Dale McHard, head, and Mr. Robert Craig, assistant engineer.

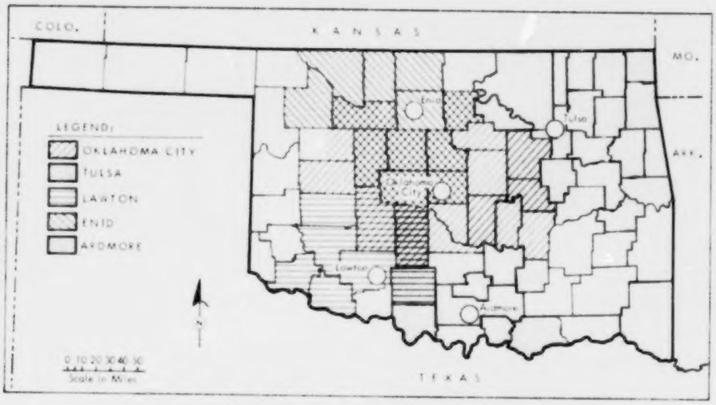

Figure 4. Oklahoma milkshed sampling areas

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1967	July 1967
April–June 1967	October 1967

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4. Tennessee Milk Network
July–September 1967

Division of Preventable Diseases
Department of Public Health
State of Tennessee

The Tennessee Department of Public Health began sampling pasteurized milk for radionuclide analysis in July of 1965. Currently the Department is collecting semimonthly milk samples from three cities (figure 5). In order to obtain a representative sample of the milk consumed in the areas monitored, a sample of milk is collected from each milk distributor supplying the city. The samples from the individual distributors are then composited in proportion to the contribution each makes to the total city milk supply.

Analytical procedures

The semimonthly milk samples from each city sampled are analyzed by gamma-ray scintillation spectrometry for potassium–40, iodine–131, cesium–137, and barium–140, using a 3½-liter sample. After gamma-ray analysis, the samples are stored for 2 weeks to allow ingrowth of daughter radioactivity, after which strontium–89, strontium–90, and barium–140 concentrations are determined radiochemically using ion-exchange procedures. Chemical analyses are also made for stable calicum and potassium.

The Chattanooga milk sample is monitored by both the State and the Public Health Service's Southeastern Radiological Health Laboratory. This dual examination of aliquot samples provides a crosscheck between the two laboratories.

Results

The monthly average stable element and radionuclide concentrations in Tennessee pasteurized milk are presented in table 3 for the period of July through September 1967.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1967	July 1967
April–June 1967	October 1967

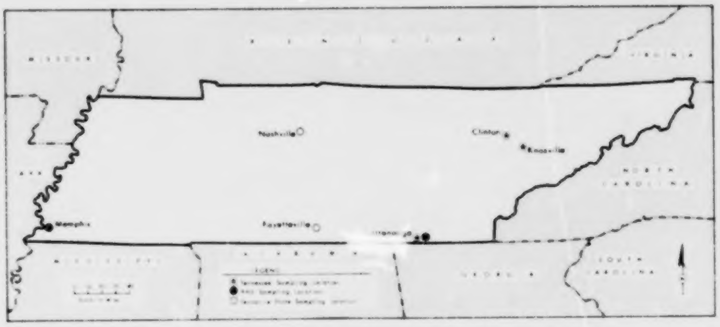

Figure 5. Tennessee pasteurized milk sampling stations

Table 3. Radionuclides in Tennessee pasteurized milk, July–September 1967

Location	Month 1967	Concentration (g/liter)	Radionuclide concentration (pCi/liter)				
		Potassium	Strontium-89	Strontium-90	Iodine-131	Cesium-137	Barium-140
Chattanooga	July	1.4	<5	20	10	22	<5
	August	1.4	<5	16	13	19	<5
	September	1.4	<5	23	<8	18	<5
Clinton	July	1.4	<5	18	<8	19	<5
	August	1.5	<5	18	11	36	<5
	September	1.3	<5	17	8	24	<5
Knoxville	July	1.4	<5	16	15	21	<5
	August	1.4	<5	16	13	12	6
	September	1.4	<5	15	<8	13	<5

5. Texas Milk Network July–September 1967

Texas State Department of Health [2]

The Texas State Department of Health initiated a Statewide milk sampling network for radionuclide content in April 1964. At present, monthly samples of raw milk are collected from each of seven "active" sampling points. In addition, six "standby" stations are collecting raw milk samples once each calendar quarter. The station locations shown in figure 6 were chosen to give maximum geographical and population coverage.

Samples are routinely analyzed for strontium–90 by a chemical separation technique employing ion exchange columns (*6*). Prepared samples are counted for 100 minutes in a low-background beta-particle counter.

Potassium–40, iodine–131, cesium–137 and barium–140 concentrations are determined by gamma-ray spectrometry. The procedure employs a 4- by 4-inch sodium-iodide crystal and a 400-channel analyzer. Samples are counted for 100 minutes in a 3.5-liter Marinelli beaker. The matrix method of calculation is used and detection limits at the 95-percent confidence level are 10 pCi/liter.

Results

Potassium–40, strontium–90 and cesium–137 results by station and month for July through September 1967 are presented in table 4. During this time, the iodine–131, and barium–140

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[2] Acknowledgment is accorded to the staff of the Radiation Control Program, Division of Occupational Health and Radiation Control, under the direction of Mr. Martin C. Wukasch, chief engineer.

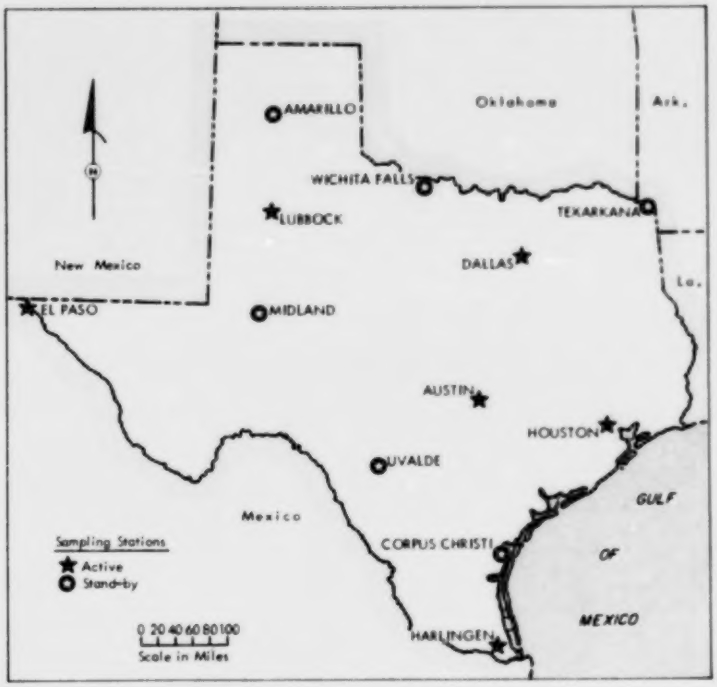

Figure 6. Texas milk sampling stations

concentrations were below their limits of detectability (10 pCi/liter). A summary of radionuclide concentrations in Texas milk for the period from April 1964 through September 1967 is presented in figure 7.

Comparison of the observed radionuclide concentrations with the Federal Radiation Council guides for peacetime operation indicates that at no time during the period of surveillance did the radionuclide concentrations in Texas milk approach levels suggesting any remedial action (*7*).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1967	July 1967
April–June 1967	October 1967

Table 4. Radionuclide concentrations in Texas raw milk network July–September 1967

Sampling location	Radionuclide concentration (pCi/liter)								
	Potassium-40			Strontium-90			Cesium-137		
	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept
Austin	1,300	1,320	1,360	3	3	4	5	3	5
Fort Worth	1,260	1,330	1,290	7	6	5	10	5	ND
El Paso	1,340	1,310	NA	2	ND	NA	<5	ND	NA
Harlingen	1,320	1,310	1,350	1	1	2	<5	ND	ND
Houston	1,360	1,290	1,270	6	9	10	15	15	5
Lubbock	1,310	1,310	1,250	5	3	3	5	5	5
San Antonio	1,300	1,290	NA	2	2	NA	5	5	NA
Average	1,310	1,310	1,300	4	4	5	7	7	5

NA, no analysis.
ND, nondetectable.

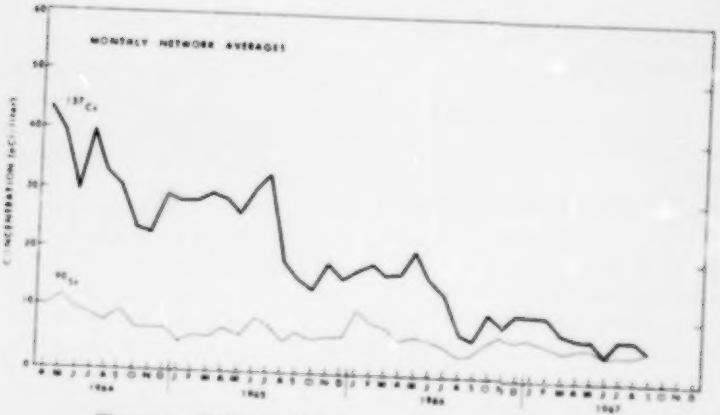

Figure 7. Radionuclide concentrations in Texas milk April 1964–September 1967

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(3) FLORIDA STATE BOARD OF HEALTH, DIVISION OF RADIOLOGICAL HEALTH. Florida milk network, July–December 1964. Radiol Health Data 6:611–612 (November 1965).

(4) PORTER, C. and M. W. CARTER. Field method for rapid collection of iodine-131 from milk. Public Health Rep 80:453–456 (May 1965).

(5) OKLAHOMA STATE DEPARTMENT OF HEALTH. Oklahoma milk network, October–December 1966. Radiol Health Data 8:203–204 (April 1967).

(6) PORTER, C. and B. KAHN. Improved determination of strontium-90 in milk by ion exchange method. Anal Chem 36:676–678 (March 1964).

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nation-wide dietary intakes of radionuclides. Periodically, results from the United Kingdom Diet Survey, conducted by the United Kingdom Agricultural Research Council Radiobiological Laboratory, are presented for comparison with data observed in the United States. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Last presented
California Diet Study	January–February 1967	October 1967
Connecticut Standard Diet	January–June 1967	November 1967
Tri-City Diet, HASL	August–December 1966	September 1967
United Kingdom Diet, ARCRL	Annual summary 1965	December 1966

1. Radionuclides in Institutional Diet Samples April–June 1967

National Center for Radiological Health
Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the National Center for Radiological Health with the assistance of the National Center for Urban and Industrial Health (*1*).

The program was designed to provide estimates of the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of July 1964, its scope had increased to boarding schools or institutions in 51 municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsequent experience with the diets of school children of various ages indicated that the number of institutions sampled could be selectively reduced. As of July 1965, 21 institutions, distributed geographically as shown in figure 1, were being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, while teenage boys consumed 20 percent more food per day (*1,2*). Consequently, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. Each sample supplied

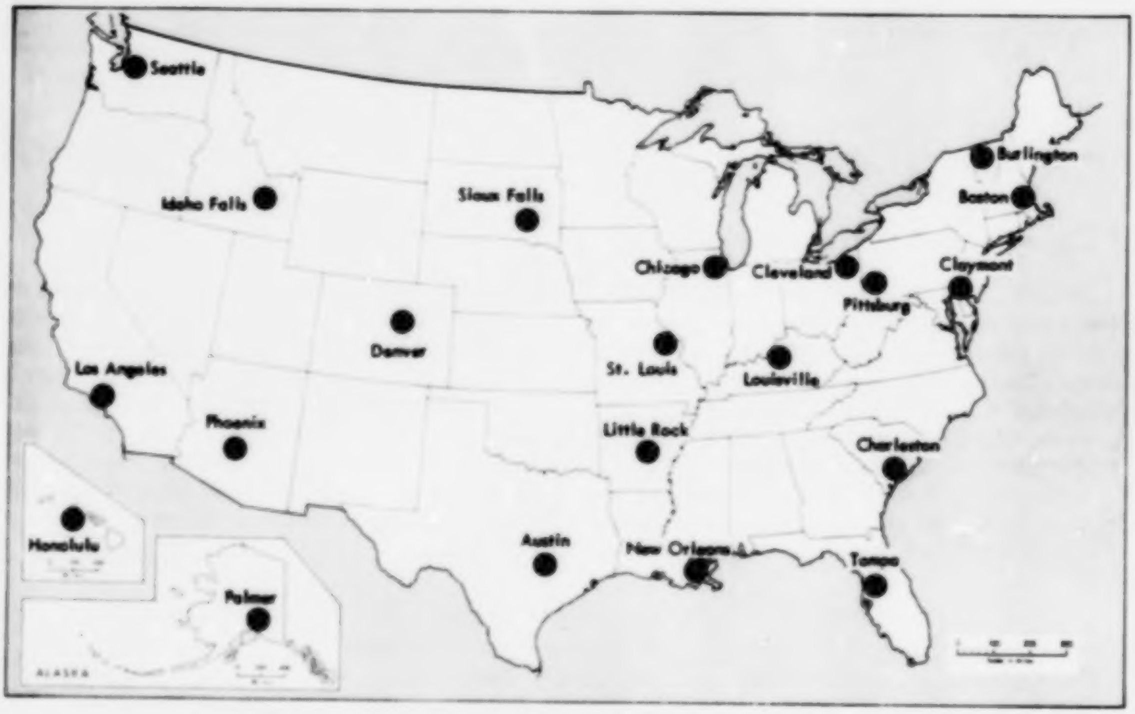

Figure 1. Institutional diet sampling locations as of July 1965

Table 1. Concentrations and intake of stable elements and radionuclides in Institutional total diets of children (9-12 years of age), April–June 1967

Location of institution	1967 month	Total weight (kg/day)	Calcium g/kg	Calcium g/day	Potassium g/kg	Potassium g/day	Strontium-89 pCi/kg	Strontium-89 pCi/day	Strontium-90 pCi/kg	Strontium-90 pCi/day	Cesium-137 pCi/kg	Cesium-137 pCi/day	Radium-226 pCi/kg	Radium-226 pCi/day
Alaska: Palmer	April	1.31	0.7	0.9	2.2	2.9	<5	5	9	12	25	35	0.5	0.7
	May	1.22	0.6	0.7	2.0	2.4	<5	5	7	9	25	30	1.1	1.3
	June	1.63	0.4	0.7	1.3	2.1	<5	5	5	8	15	25	0.9	1.5
Ariz: Phoenix	April	1.61	0.8	1.3	1.7	2.7	<5	5	7	11	15	25	0.7	1.1
	May	1.88	0.6	1.1	1.4	2.6	<5	5	4	8	10	20	0.7	1.3
	June	1.60	0.7	1.1	1.7	2.7	5	10	7	11	10	15	0.7	1.1
Ark: Little Rock	April	1.38	0.5	0.7	1.4	1.9	NA	NA	10	14	20	30	0.9	1.2
	May	1.38	0.6	0.8	1.5	2.1	NA	NA	14	19	15	20	0.9	1.2
	June	1.11	0.5	0.6	1.6	1.8	NA	NA	13	14	20	20	1.0	1.1
Calif: Los Angeles	April	2.12	0.8	1.7	1.7	3.6	<5	5	4	8	15	30	0.7	1.5
	May	1.85	0.8	1.5	1.7	3.1	<5	5	5	9	10	20	0.6	1.1
	June	2.13	1.1	2.3	1.5	3.2	<5	5	5	11	10	20	0.4	0.9
Colo: Denver	April	2.15	0.7	1.5	1.6	3.4	<5	5	7	15	15	30	0.4	0.9
	May	2.08	0.6	1.2	1.8	3.7	<5	5	7	15	15	30	0.8	1.7
	June	1.98	0.8	1.6	1.6	3.2	<5	5	6	12	25	50	0.8	1.6
Del: Wilmington	April	2.19	0.7	1.5	1.9	4.2	<5	5	9	20	10	20	0.6	1.3
	May	2.11	0.7	1.5	1.9	4.0	<5	5	8	17	15	30	0.6	1.3
	June	2.34	0.8	1.9	1.7	4.0	<5	5	12	28	30	70	1.1	2.6
Fla: Tampa	April	2.05	0.5	1.0	1.7	3.5	NA	NA	7	14	35	70	1.5	3.1
	May	2.07	0.5	1.0	1.8	3.7	NA	NA	8	17	40	85	1.4	2.9
	June [a]	2.02	0.6	1.2	1.8	3.6	NA	NA	7	14	50	100	1.4	2.8
Hawaii: Honolulu	April	2.50	0.4	1.0	1.3	3.3	<5	5	4	10	15	35	0.7	1.8
	May	2.33	0.5	1.2	1.4	3.3	<5	5	3	7	15	35	0.6	1.4
	June	2.37	0.4	0.9	1.7	4.0	<5	5	2	5	25	60	0.4	0.9
Idaho: Idaho Falls	April [a]	2.09	0.8	1.7	1.9	4.0	<5	5	8	17	10	20	0.4	0.8
	May [a]	1.82	1.3	2.4	1.7	3.1	<5	5	7	13	20	35	0.9	1.6
	June [a]	1.56	1.0	1.6	1.8	2.8	<5	<2	[b]2	1	15	25	0.6	0.9
Ill: Chicago	April	1.54	0.6	0.9	1.7	2.6	<5	5	7	11	10	15	0.6	0.9
	May	1.95	0.8	1.6	1.6	3.1	<5	5	8	16	15	30	0.7	1.4
	June	1.59	0.7	1.1	1.6	2.5	<5	5	8	13	15	25	0.7	1.1
Ky: Louisville	April [a]	1.67	0.8	1.3	1.5	2.5	NA	NA	11	18	15	25	1.3	2.2
	May [a]	1.63	0.8	1.3	1.6	2.6	NA	NA	12	20	10	15	1.2	2.0
	June [a]	1.75	0.7	1.2	1.7	3.0	NA	NA	12	21	15	25	0.9	1.6
La: New Orleans	April	1.48	0.5	0.7	1.5	2.2	<5	5	12	18	15	20	0.7	1.0
	May	1.84	0.7	1.3	2.0	3.7	<5	5	14	26	55	100	1.2	2.0
	June	1.78	0.6	1.1	1.5	2.7	<5	5	10	18	20	35	1.2	2.1
Mass: Boston	April	1.80	0.7	1.3	1.6	2.9	<5	5	10	18	30	55	0.7	1.3
	May	1.52	0.9	1.4	1.6	2.4	<5	5	11	17	25	40	0.6	0.9
	June	1.50	0.8	1.2	1.7	2.6	<5	5	11	17	15	25	0.5	0.8
Mo: St. Louis	April	1.33	0.9	1.2	1.7	2.3	<5	5	11	15	10	15	0.5	0.7
	May	1.52	0.9	1.4	1.7	2.6	<5	5	15	23	15	25	0.6	0.9
	June	2.08	0.8	1.7	1.9	4.0	<5	5	14	29	10	20	1.0	2.1
Ohio: Cleveland	April	1.43	0.6	0.9	2.1	3.0	<5	5	7	10	10	15	0.6	0.9
	May	1.33	0.7	0.9	2.0	2.7	<5	5	9	12	20	25	0.7	0.9
	June	1.48	0.7	1.0	2.1	3.1	<5	5	7	10	20	30	0.6	0.9
Pa: Pittsburgh	April [a]	2.22	0.6	1.3	1.5	3.3	<5	5	10	22	20	45	0.7	1.6
	May [a]	2.22	0.6	1.3	1.5	3.3	<5	5	7	16	10	20	0.6	1.3
	June [a]	2.20	0.6	1.3	1.6	3.5	<5	5	10	22	10	20	0.9	2.0
S. C: Charleston	April	1.36	0.6	0.8	1.4	1.9	<5	5	9	12	30	40	1.6	2.2
	May	1.44	0.7	1.0	1.5	2.2	<5	5	11	16	20	30	1.7	2.4
	June	1.96	0.6	1.2	1.4	2.7	<5	5	8	16	30	60	1.4	2.7
S. Dak: Sioux Falls	April	1.05	0.7	0.7	1.6	1.7	<5	5	6	6	15	15	0.6	0.6
	May	1.15	0.7	0.8	1.7	2.0	<5	5	8	9	20	25	0.7	0.8
	June	1.25	0.6	0.8	1.7	2.1	<5	5	6	8	15	20	1.0	1.3
Tex: Austin	April	1.69	0.6	1.0	1.3	2.2	NA	NA	5	8	10	15	0.8	1.4
	May	1.83	0.6	1.1	1.1	2.0	NA	NA	5	9	5	10	0.8	1.5
	June	1.76	0.6	1.1	1.4	2.5	NA	NA	5	9	15	25	0.7	1.2
Vt: Burlington	April	0.92	0.8	0.7	1.8	1.7	<5	5	13	12	15	15	0.5	0.5
	May	1.18	0.8	0.9	1.6	1.9	<5	5	11	13	20	25	0.6	0.7
	June	1.16	0.6	0.7	2.0	2.3	<5	5	8	9	15	15	0.6	0.7
Wash: Seattle	April [a]	1.59	0.7	1.1	1.9	3.0	<5	5	8	13	15	25	0.4	0.6
	May [a]	1.88	0.6	1.1	1.7	3.2	<5	5	11	21	35	65	1.0	1.9
	June [a]	1.83	0.6	1.1	1.6	2.9	<5	5	7	13	30	55	0.8	1.5
Institutional average	April	1.64	0.7	1.0	1.7	2.7	<5	5	8	13	20	30	0.7	1.2
	May	1.72	0.7	1.1	1.7	2.8	<5	5	9	14	20	35	0.8	1.5
	June	1.73	0.7	1.2	1.7	2.8	<5	5	8	14	20	30	0.8	1.6

[a] Since food samples were collected from two or more children who were over 12 years of age, data for this month were not used in institutional average.

[b] Less than 2 pCi/kg of strontium-90 was interpreted as 1 pCi/kg for the purpose of obtaining dietary intakes.

NA-no analysis

NOTE: Since iodine-131 and barium-140 were not detectable at most stations during the second quarter 1967 no provision was made for these nuclides in the table. The one exception is as follows: Iodine-131 was reported in May for Phoenix, Ariz (13 pCi/kg).

monthly by each institution represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily food sample is kept frozen until the end of the collection period, and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nev.; the Southeastern Radiological Health Laboratory, Montgomery, Ala.; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures was presented earlier (*3*).

Results

Table 1 presents the analytical results for institutional diet samples collected from April through June, 1967, for children 9 to 12 years of age. The stable elements, calcium and potassium, are reported in g/kg of diet, and the radionuclide concentrations of these samples, reported in pCi/kg of diet, are corrected for radioactive decay to the midpoint of the sample collection period, where applicable. Dietary intakes, in g/day or pCi/day, were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. For the purpose of obtaining dietary intakes, "less than" 5 pCi/kg of strontium–89 was interpreted as 2.5 pCi/kg. The average food consumption rate during this period was 1.70 kg/day compared to the network average of 1.90 kg/day observed from 1961 through 1964 (*4*).

Strontium–90 dietary intake during this period averaged 14 pCi/day. This result falls within Range I as defined by the Federal Radiation Council (*5*). Cesium–137 intakes averaged 32 pCi/day during this period. Strontium–89, barium–140, and iodine–131 concentrations were generally below detectable levels.

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(*2*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in Institutional total diet samples. January–March 1965. Radiol Health Data 6:548–554 (October 1965).

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(*4*) GRUNDY, R. D., C. CALVERT, and A. G. BERGER. Summary of results of Institutional Total Diet Sampling Network, 1961–1964. Radiol Health Data 6:691–698 (December 1965).

(*5*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December 1966	July 1967
January–March 1967	October 1967

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below:

Activity	Period reported	Last presented
California Water Sampling Program	January–June 1966	June 1967
Coast Guard Water Sampling Program	1966	November 1967
Radiostrontium in Tap Water, HASL	March–November 1966	June 1967
Washington Surface Water Sampling	July 1965–June 1966	August 1967

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Gross Radioactivity in Surface Waters of the United States July 1967

Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the August 1967 issue of *Radiological Health Data and Reports*.

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1-6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the

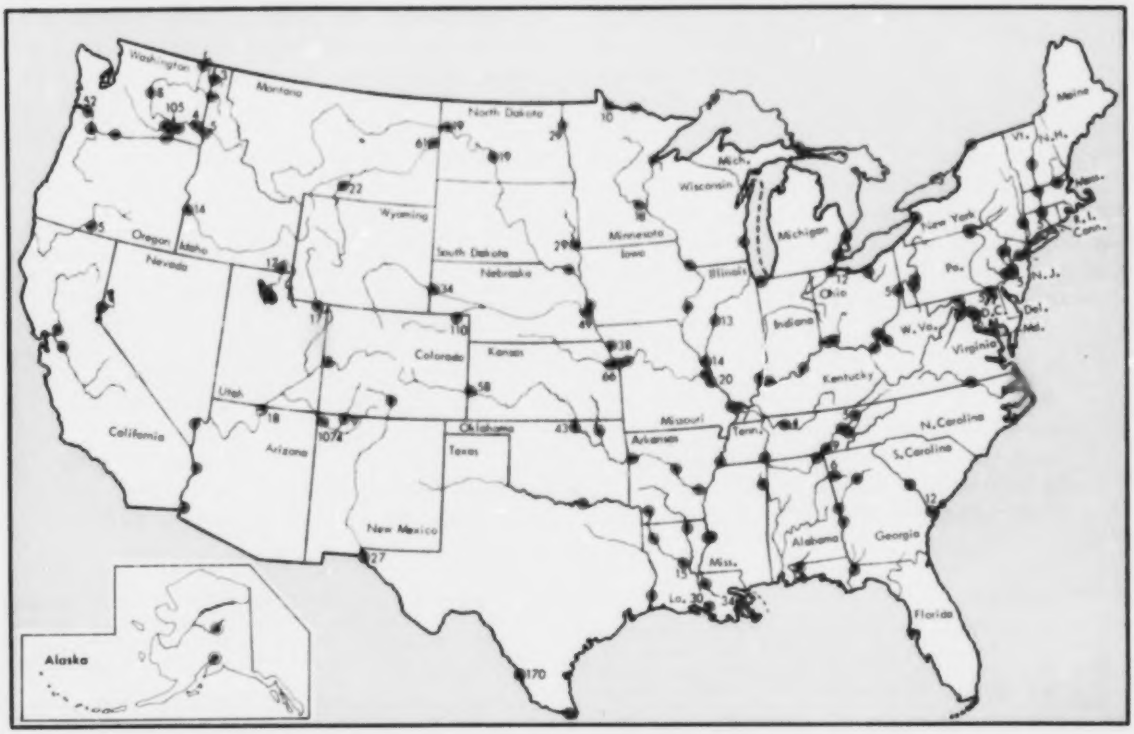

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, July 1967

selection of certain data for comment. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations of the Water Pollution Surveillance System for 1961 through 1965 has been presented (7). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During both June and July, the following stations showed values in excess of 15 pCi/liter on alpha radioactivity for either suspended or dissolved solids:

South Platte River; Julesburg, Colo.
Yellowstone River; Sidney, Mont.

In July, the Coolidge, Kans., station showed a value in excess of 15 pCi/liter on alpha radioactivity in dissolved solids.

The following stations decreased to less than 15 pCi/liter on alpha radioactivity on either suspended or dissolved solids:

Arkansas River; Ponca City, Okla.
Kansas River; DeSoto, Kans.
Missouri River; St. Joseph, Mo.
Platte River; Plattsmouth, Nebr.

Table 1. Radioactivity in raw surface waters, July 1967

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	<1	1	1	2	7	9
Arkansas River:						
Coolidge, Kans.	9	21	30	25	33	58
Ponca City, Okla.	3	6	9	15	28	43
Atchafalaya River:						
Morgan City, La.	8	1	9	23	7	30
Bear River:						
Preston, Idaho	0	2	2	2	15	17
Big Horn River:						
Hardin, Mont.	1	3	4	6	16	22
Big Sioux River:						
Sioux Falls, S. Dak.	2	2	4	6	23	29
Clearwater River:						
Lewiston, Idaho	<1	0	<1	3	2	5
Clinch River:						
Clinton, Tenn.	0	0	0	1	4	5
Colorado River:						
Page, Ariz.	0	5	5	0	18	18
Columbia River:						
Wenatchee, Wash.	1	0	1	4	4	8
Pasco, Wash.*	0	<1	<1	24	81	105
Clatskanie, Ore.	0	<1	<1	15	37	52
Connecticut River:						
Enfield Dam, Conn.	0	0	0	2	3	5
Coosa River:						
Rome, Ga.	1	0	1	3	3	6
Cumberland River:						
Cheatham Lock, Tenn.	0	0	0	1	3	4
Delaware River:						
Philadelphia, Pa.	0	0	0	1	4	5
Great Lakes:						
Duluth, Minn.	0	0	0	0	1	1
Green River:						
Dutch John, Utah	0	3	3	1	16	17
Illinois River:						
Peoria, Ill.	0	2	2	3	10	13
Grafton, Ill.	0	3	3	3	11	14
Kansas River:						
DeSoto, Kans.	13	2	15	49	17	66
Klamath River:						
Keno, Ore.	0	0	0	1	4	5
Maumee River:						
Toledo, Ohio	0	2	2	1	11	12
Mississippi River:						
St. Paul, Minn.	0	3	3	2	16	18
E. St. Louis, Ill.	1	1	2	10	10	20
New Orleans, La.	7	0	7	25	9	34
Missouri River:						
Williston, N. Dak.	4	2	6	11	8	19
Bismarck, N. Dak.	1	3	4	4	15	19
St. Joseph, Mo.	4	4	8	18	20	38
North Platte River:						
Henry, Nebr.	4	14	18	10	24	34
Ohio River:						
Toronto, Ohio	0	0	0	0	5	5
Cairo, Ill.	1	0	1	3	4	7
Pend Oreille River:						
Albeni Falls Dam, Idaho	0	1	1	1	2	3
Platte River:						
Plattsmouth, Nebr.	7	6	13	21	28	49
Potomac River:						
Washington, D. C.	0	0	0	1	5	6
Rainy River:						
Baudette, Minn.	0	0	0	1	8	9
Red River, North:						
Grand Forks, N. Dak.	1	3	4	4	25	29
Red River, South:						
Alexandria, La.	0	2	2	4	11	15
Rio Grande:						
El Paso, Tex.	1	3	4	9	18	27
Laredo, Tex.	55	2	57	156	14	170
San Juan River:						
Shiprock, N. Mex.	276	6	282	1,048	26	1,074
Savannah River:						
Port Wentworth, Ga.*	1	<1	1	3	9	12
Snake River:						
Payette, Idaho	1	2	3	2	12	14
Wawawai, Wash.	0	1	1	1	3	4
South Platte River:						
Julesburg, Colo.	37	24	61	68	42	110
Susquehanna River:						
Conowingo, Md.	0	0	0	1	4	5
Tennessee River:						
Chattanooga, Tenn.	1	1	2	2	7	9
Yellowstone River:						
Sidney, Mont.	18	4	22	47	14	61
Maximum	276	24	282	1,048	81	1,074
Minimum	0	0	0	0	1	1

* Gross beta radioactivity at these stations may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

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Laredo, Tex., on the Rio Grande and Shiprock, N. Mex., on the San Juan River reported alpha and beta radioactivity on suspended solids in excess of 15 pCi/liter and 150 pCi/liter for July 1967.

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(*2*) *Ibid.*, 1959 Edition.

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(*7*) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961–1965. Radiol Health Data Rep 9:1–12 (January 1968).

Radioactivity in Minnesota Municipal Water Supplies[1] January–June 1967

Division of Environmental Sanitation
Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity was intiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State, as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled. At present, nine surface streams and lakes used as municipal water supplies are sampled routinely (figure 1). "Grab" samples of raw and treated water are collected weekly at Hallock, East Grand Forks, Eveleth, Fairmont, and St. Paul and monthly at Crookston, International Falls, and St. Cloud. Minneapolis tap water is analyzed weekly. No raw water is collected from the Minneapolis supply.

The samples are forwarded to the Division's laboratory, where they are analyzed for gross alpha and beta radioactivity. A 250-ml sample of water is transferred to a 2-inch planchet and evaporated at 75°C. The solid residue (suspended-plus-dissolved solids) is fixed by adding lucite in acetone. The sample is then counted for alpha or beta radioactivity in an internal-proportional counter. Counter standardization is accomplished by adding known amounts of thallium-204 standard to solutions containing the normal range of solids.

Table 1 shows a summary of the monthly average gross beta radioactivity in Minnesota municipal water supplies from January to June. 1967. Table 2 shows the gross alpha radioactivity in the same samples for the same period of time. Alpha radioactivity reported as <1 pCi/liter were coinsidered as 0.5 pCi/liter for averaging purposes.

The data obtained on gross beta radioactivity in Minnesota surface waters show a variation of concentrations, with no readily apparent trends. Variations in precipitation and flow rates of streams could contribute to this fluctuation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from 6 to 25 pCi/liter, which is well below the Public Health Service Drinking Water Standards (*1*).

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[1] Data and information from "Survey of Environmental Radioactivity, January–June 1967," Publication No. COO-651-48. State of Minnesota Department of Health, University Campus, Minneapolis, Minn. 55440.

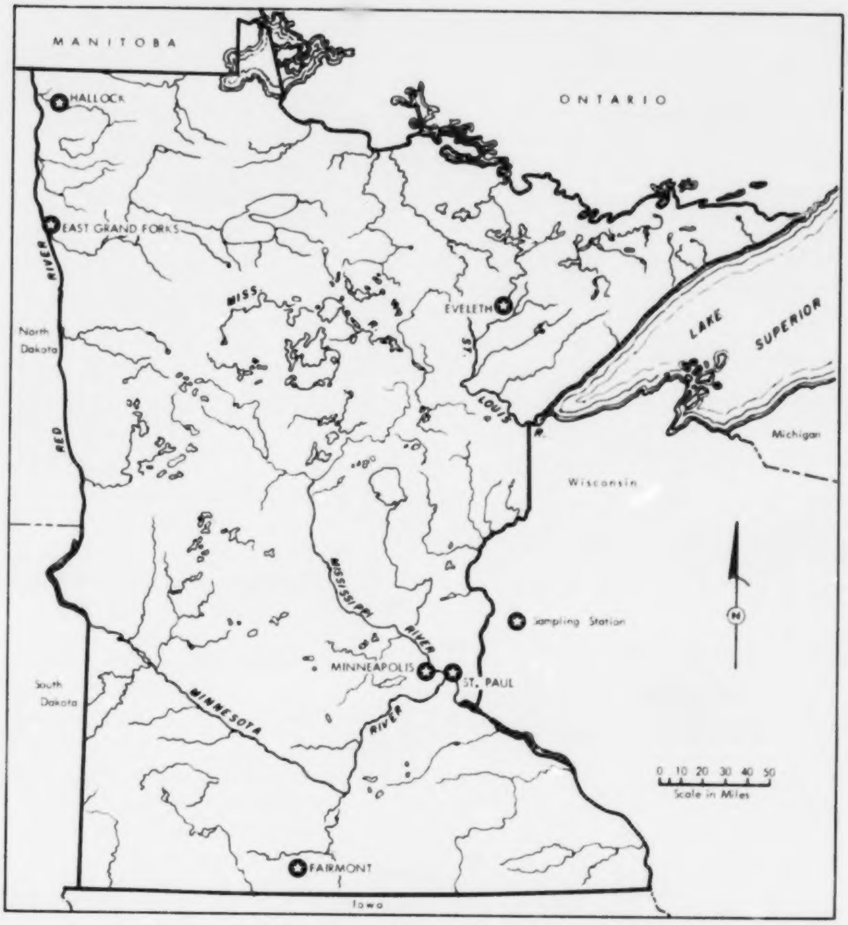

Figure 1. Minnesota surface water sampling locations

Table 1. Total beta-particle concentrations in Minnesota raw and treated water supplies, January–June 1967

Town and water source	Average concentrations (pCi/liter)						
	Type of water	Jan	Feb	Mar	Apr	May	June
Crookston, Red Lake River	Raw	18	22	16	21	19	22
	Treated	19	17	20	20	19	32
East Grand Forks, Red Lake River	Raw	20	18	19	20	25	18
	Treated	8	9	9	12	13	10
Eveleth, St. Mary's Lake	Raw	10	14	18	12	11	15
	Treated	12	10	14	12	10	12
Fairmont, Budd Lake	Raw	14	14	14	11	11	10
	Treated	6	7	9	6	8	8
Hallock, Two Rivers South Fork	Raw	23	15	20	19	22	23
	Treated	9	6	11	8	9	10
International Falls, Rainy River	Raw	7	6	10	10	13	10
	Treated	6	4	8	9	7	6
Minneapolis tap water	Raw	---	---	---	---	---	---
	Treated	4	5	5	6	4	6
St. Cloud, Mississippi River	Raw	12	9	9	12	10	9
	Treated	5	5	6	7	9	10
St. Paul, Vadnais Chain of Lakes	Raw	8	10	12	11	11	12
	Treated	4	5	4	4	6	6

Table 2. Total alpha-particle concentrations in Minnesota raw and treated water supplies, January–June 1967

Town and water source	Average concentrations (pCi/liter)						
	Type of Water	Jan	Feb	Mar	Apr	May	June
Crookston, Red Lake River	Raw	<3	<1	1	3	3	2
	Treated	<3	1	<1	<1	<1	<1
East Grand Forks, Red Lake River	Raw	1	<1	<1	4	4	1
	Treated	1	<1	<1	1	2	<1
Eveleth, St. Mary's Lake	Raw	<1	<1	<1	<1	<1	<1
	Treated	<1	<1	1	<1	1	<1
Fairmont, Budd Lake	Raw	4	5	4	3	4	4
	Treated	<1	<1	<1	<1	2	1
Halleck, Two Rivers South Fork	Raw	2	1	1	1	2	1
	Treated	<1	1	<1	<1	<1	<1
International Falls, Rainy River	Raw	<1	<1	1	<1	1	<1
	Treated	<1	1	<1	1	2	<1
Minneapolis tap water	Raw						
	Treated	<1	<1	<1	<1	<1	<1
St. Cloud, Mississippi River	Raw	<2	1	<1	<1	<1	<1
	Treated	<1	<1	<1	<1	<1	<1
St. Paul, Vadnais Chain of Lakes	Raw	<1	<1	<1	<1	<1	<1
	Treated	<1	<1	<1	<1	<1	<1

REFERENCE

(*1*) PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1966	October 1967

Radioactivity in New York Surface Water, January–September 1967[1]

Division of General Engineering and Radiological Health
State of New York Department of Health

In 1955 the New York State Department of Health began a program to determine the amount of radioactivity in water used for public consumption. Radioactivity in water may arise from any one or a combination of the following sources: the natural mineral content of water (background), atmospheric fallout, or nuclear industry operations. Water samples are obtained from 27 locations for gross beta-particle analysis (figure 1). Table 1 gives the sampling frequency and type of sample. Larger samples are collected at selected locations for strontium–90 analysis.

Analytical procedures

Strontium and other alkaline earths are precipitated as carbonates from a 500 ml sample. Iron and rare earths are removed by hydroxide scavenging, while barium is precipitated as a chromate. Strontium is finally precipitated as a sulphate from a pH controlled EDTA solu-

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[1] Due to a move of the laboratory, analyses were temporarily curtailed, therefore only January through May data are included in this report.

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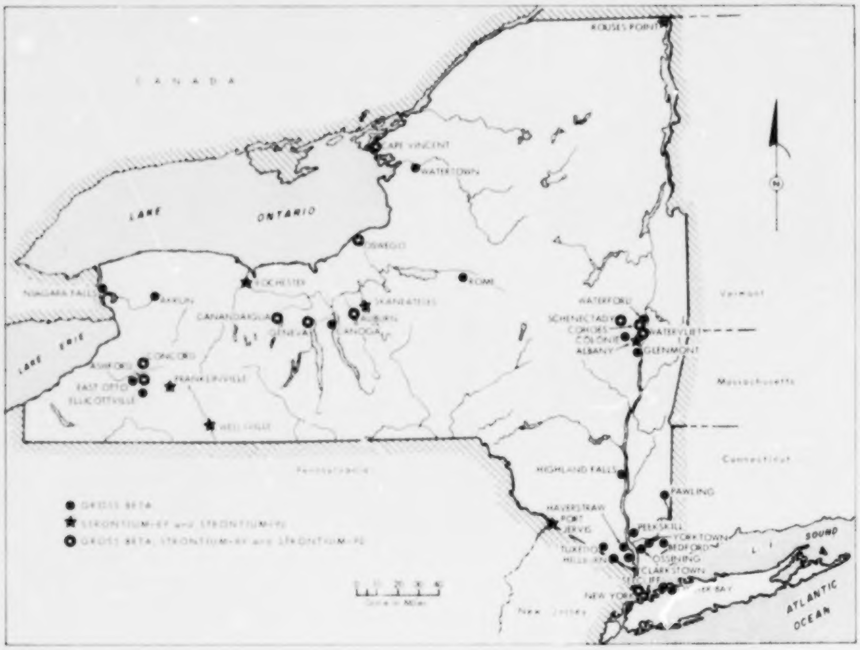

Figure 1. New York water sampling locations

tion. Calcium and yttrium remain in solution as EDTA complexes (*1,2*).

Strontium-90 is determined by yttrium-90 ingrowth counting of the final precipitate at less than 6 hours after precipitation and again at greater than 50 hours using a low background (less than 1 cpm) gas flow, proportional beta-particle counter. Strontium-89 is estimated by taking the difference between the total strontium and the strontium-90 radioactivity.

Chemical recovery is between 70 and 75 percent and results in a minimum detectable radioactivity of 3 pCi/liter ± 100 percent at the 95-percent confidence level.

Discussion and results

The observed gross beta-particle concentrations in New York surface water for January–May 1967 are given in table 1. It should be noted that the Cohoes gross beta-particle results are for a raw water sample, while the Cohoes radiostrontium results are for a finished water sample.

The average concentrations of strontium-89 and strontium-90 in New York water for April through September 1967 for the Concord station are given in table 2.

REFERENCES

(*1*) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Improved determination of strontium-90 in milk by ion-exchange method. Anal Chem 33:1306–1308 (September 1961).

(2) WELFORD, G. and SUTTON, D., a paper presented at the American Chemical Society meeting in New York City, September, 1960.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1965	June 1966
January–December 1966	September 1967

Table 1. Gross beta radioactivity in New York raw surface water, January–May 1967

Location	Sampling [a]	Gross beta radioactivity (pCi/liter)				
		Jan	Feb	Mar	Apr	May
Akron	BW	8	6	NS	NS	NS
Albany	BW	NS	2	4	3	NS
Ashford (Buttermilk Creek)	W	NS	NS	175	312	72
Brant (Cattaraugus Creek)	W	NS	NS	52	17	NS
Cohoes (Mohawk River)	D	4	4	4	4	NS
Collins (Cattaraugus Creek)	M	NS	7	60	16	NS
Colonie (Patroon Creek)	SA	NS	NS	NS	NS	8
Concord (Cattaraugus Creek)	D	101	157	60	41	129
Geneva (Seneca Lake)	SA	NS	4	4	4	NS
Glenmont (Hudson River)	D	5	4	6	10	NS
Highland Falls (Bog Meadow Brook)	M	NS	3	NS	NS	NS
Lansing	SA	NS	NS	NS	NS	8
New York City	SA	NS	5	3	NS	NS
Niagara Falls (East Branch Niagara River)	Q	NS	6	NS	6	NS
(West Branch-Niagara River)	Q	NS	4	NS	NS	NS
Ossining (Hudson River)	D	35	9	23	1	NS
(Indian Brook Reservoir)	M	6	4	NS	5	NS
Oswego (Lake Ontario)	M	4	4	NS	4	4
Pawling (Pond at United Nuclear)	M	NS	NS	5	4	NS
Peekskill (Camp Field Water Supply)	M	6	NS	5	4	NS
(Hudson River)	D	25	18	20	4	NS
Rome (Fish Creek)	BW	4	NS	NS	NS	NS
Schenectady (Mohawk River)	C	5	4	3	4	NS
Tuxedo (Indian Hill)	M	NS	3	5	3	NS
Watertown (Black River)	BW	13	4	4	5	4
Watervliet (French Mills Reservoir)	BW	4	4	NS	NS	NS
Yorktown (Croton Reservoir)	M	2	7	NS	4	NS

[a] BW-Biweekly composite of daily grab samples.
D-Weekly composite of daily grab samples.
C-Continuous bleed-off-analyzed weekly.
M-Monthly grab sample.
Q-Quarterly grab sample.
SA-Semiannual grab sample.
NS, no sample.

Table 2. Strontium-89 and strontium-90 in New York surface waters, April–September 1967

Location	Month 1967	Radionuclide concentration (pCi/liter)	
		Strontium-89	Strontium-90
Concord [a] (Springville Power Dam on Cattaraugus Creek)	April	<3	21
	May	9	13
	July	NA	38
	August	NA	53
	September	NA	15

[a] These samples were collected from a sampling station located downstream from the Nuclear Fuel Services Spent Fuel Processing Plant located in Cattaraugus County.
NA, no analysis.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta-particle analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
HASL Fallout Network	July-December 1966	September 1967
HASL 80th Meridian Network	Calendar Year 1965	January 1967
Plutonium in Airborne Particulates	January–March 1967	September 1967

1. Radiation Surveillance Network
September 1967

National Center for Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples at 73 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Md., for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta radioactivity by the station operators. These estimates are made after the decay of radon and partial decay of thoron daughter products and prior to submission of the samples for laboratory analysis. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*1*). A detailed description of the sampling and analytical procedures was presented in the November 1966 issue of *Radiological Health Data and Reports*. The described procedures have been modified in that laboratory gross beta radioactivity analysis and gamma-ray spectroscopy are no longer performed on air samples having a field estimate below 10 pCi/m^3. Reporting field estimates only may cause an apparent increase in the published airborne radioactivity levels proportional to the amount of thoron daughter radioactivity present in the sample. In extreme cases, this increase may be as much as 2 orders of magnitude, but usually will be of the order of a factor of 2 or less. The maximum field estimates reported by RSN stations attributable to thoron daughter radioactivity have ranged from 15 to 20 pCi/m^3 at 5 hours after collection.

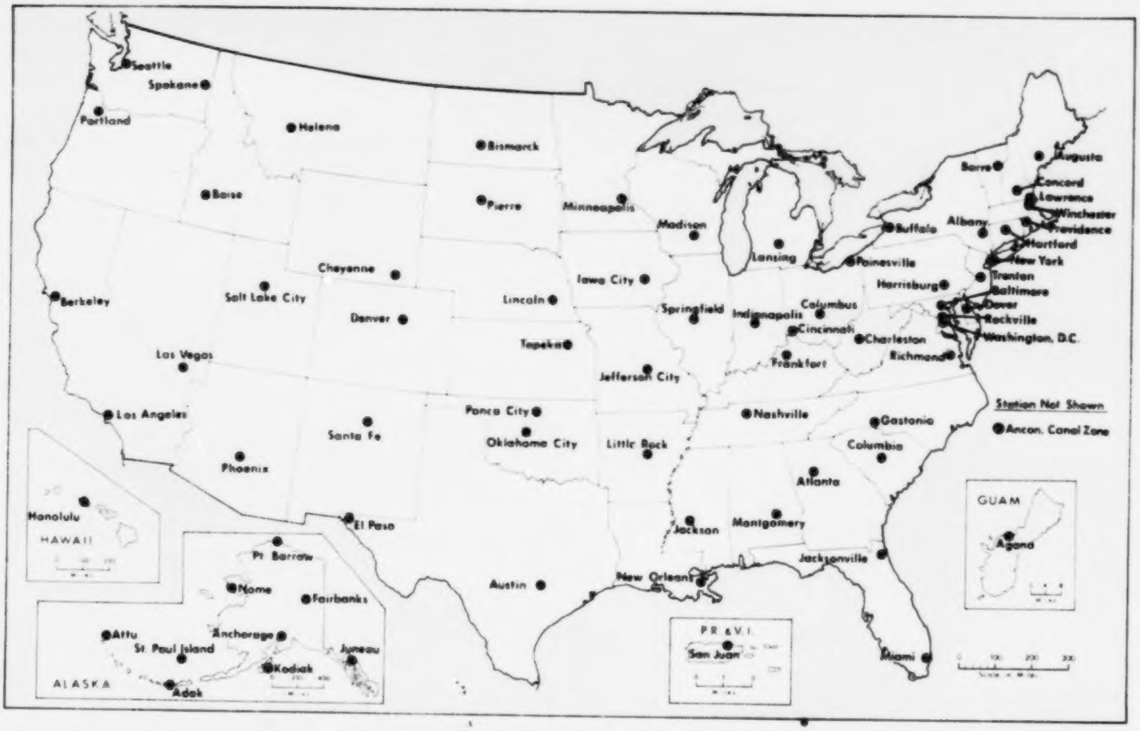

Figure 1. Radiation Surveillance Network sampling stations

Table 1 presents the monthly average gross beta radioactivity in surface air particulates as measured by the field estimate and deposition by precipitation during September 1967. Time profiles of gross beta radioactivity in air for eight RSN stations are shown in figure 2.

Table 1. Gross beta radioactivity in surface air and precipitation, September 1967

Station location		Number of samples		Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation	
		Air	Pptn	Maximum	Minimum	Average [a]		Total depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	30	5	8.50	0.28	2.54	Nov 67	162	<33
Alaska:	Adak	30	....	.36	0.36	.36	June 67	(c)	....
	Anchorage	20	8	.00	.00	.00	Dec 67	81	<16
	Attu Island	(b)	....	....	....	....	July 67	(c)	....
	Fairbanks	(b)	....	....	....	....	Jan 68	(c)	....
	Juneau	20	18	.49	.00	.12	Apr 67	306	<62
	Kodiak	11	....	1.45	.29	.71	May 67	(c)	....
	Nome	5	....	.97	.00	.67	Sept 67	(c)	....
	Pt. Barrow	30	....	.62	.59	.60	Aug 67	(c)	....
	St. Paul Island	(b)	....	....	....	....	Oct 67	(c)	....
Ariz:	Phoenix	(b)	....	....	....	....	Apr 67	(c)	....
Ark:	Little Rock	16	8	2.00	.57	1.20	Dec 67	145	<29
Calif:	Berkeley	20	....	1.24	.00	.23	May 67	(c)	....
	Los Angeles	19	3	.97	.20	.48	Sept 67	8	< 2
C. Z:	Ancon	16	....	2.00	.67	1.32	May 67	(c)	....
Colo:	Denver	16	....	6.01	.14	3.12	May 67	(c)	....
Conn:	Hartford	20	5	1.01	.23	.44	Jan 68	36	< 7
Del:	Dover	19	....	2.23	.21	.70	Nov 67	(c)	....
D. C:	Washington	30	2	3.02	.25	1.03	Aug 67	10	< 2
Fla:	Jacksonville	20	3	1.03	.25	.37	Dec 67	36	< 7
	Miami	17	8	.23	.07	.15	Jan 68	136	<27
Ga:	Atlanta	19	3	3.27	.39	1.08	Oct 67	47	<10
Guam:	Agana	29	....	2.49	.00	.47	Nov 67	(c)	....
Hawaii:	Honolulu	30	....	.80	.31	.41	July 67	(c)	....
Idaho:	Boise	29	1	6.36	.82	2.23	July 67	9	< 2
Ill:	Springfield	20	4	6.50	.00	1.74	Aug 67	76	<15
Ind:	Indianapolis	19	4	7.48	.70	1.98	Oct 67	16	< 3
Iowa:	Iowa City	21	4	10.33	.53	2.40	May 67	69	<14
Kans:	Topeka	16	7	12.12	.64	3.61	Dec 67	100	<20
Ky:	Frankfort	16	5	6.34	.71	2.45	Aug 67	31	< 6
La:	New Orleans	20	....	1.46	.04	.23	Aug 67	(c)	....
Maine:	Augusta	21	5	1.82	.08	.58	Sept 67	91	<18
Md:	Baltimore	19	1	3.47	.19	1.19	Jan 68	5	< 1
	Rockville	4	....	.78	.05	.34	July 67	(c)	....
Mass:	Lawrence	17	7	3.88	.59	1.41	Nov 67	72	<15
	Winchester	19	6	4.91	.00	1.03	June 67	55	<11
Mich:	Lansing	19	6	6.56	.51	1.98	July 67	42	< 8
Minn:	Minneapolis	20	3	.42	.18	.24	Nov 67	22	< 4
Miss:	Jackson	18	3	2.78	.14	.81	Sept 66	50	<13
Mo:	Jefferson City	20	7	3.19	.19	.94	Oct 67	75	<15
Mont:	Helena	20	3	3.45	.25	1.21	June 67	7	< 1
Nebr:	Lincoln	18	9	2.80	.22	1.11	Oct 67	74	<15
Nev:	Las Vegas	26	....	1.74	.22	.58	Jan 68	(c)	....
N. H:	Concord	19	....	3.30	.46	1.12	Aug 67	(c)	....
N. J:	Trenton	20	1	1.06	.21	.47	Sept 67	2	< 1
N. Mex:	Santa Fe	20	6	1.46	.21	.57	June 67	30	< 6
N. Y:	Albany	21	5	1.87	.17	.73	Oct 67	48	<10
	Buffalo	12	....	1.19	.07	.42	May 67	(c)	....
	New York City	20	....	.37	.13	.21	June 67	(c)	....
N. C:	Gastonia	16	....	15.02	1.10	5.10	May 67	(c)	....
N. Dak:	Bismarck	19	6	3.54	.77	1.84	Aug 67	55	<11
Ohio:	Cincinnati	20	....	6.52	.58	2.87	Nov 67	(c)	....
	Columbus	19	3	4.56	.00	1.70	Sept 67	57	<11
	Painesville	19	5	3.15	.29	1.20	Jan 68	59	<12
Okla:	Oklahoma City	18	1	1.01	.00	.19	July 67	56	<11
	Ponca City	22	8	1.37	.08	.52	Jan 68	173	<35
Ore:	Portland	19	2	2.33	.24	.81	Oct 67	9	< 2
Pa:	Harrisburg	19	....	3.27	.53	1.36	Oct 67	(c)	....
P. R:	San Juan	11	2	.44	.00	.03	Sept 67	50	<10
R. I:	Providence	20	4	.98	.00	.32	July 67	60	<12
S. C:	Columbia	9	3	1.13	.00	.38	June 67	95	<19
S. Dak:	Pierre	17	....	7.48	.97	3.10	Apr 67	(c)	....
Tenn:	Nashville	19	4	4.58	.11	1.31	July 67	81	<16
Tex:	Austin	19	....	6.98	.01	3.01	Nov 67	(c)	....
	El Paso	30	5	5.70	.76	2.02	Aug 67	24	< 5
Utah:	Salt Lake City	30	5	1.25	.22	.50	Sept 67	20	< 4
Vt:	Barre	19	6	2.42	.00	.92	Dec 67	56	<11
Va:	Richmond	17	4	1.64	.22	.81	Dec 67	15	< 3
Wash:	Seattle	13	....	.55	.00	.05	Dec 67	(c)	....
	Spokane	20	1	2.91	.41	1.21	Nov 67	3	< 1
W. Va:	Charleston	19	6	3.14	.24	1.37	June 67	43	< 9
Wis:	Madison	20	5	2.48	.32	.96	Dec 67	62	<12
Wyo:	Cheyenne	20	3	5.97	.95	2.45	Jan 68	22	< 5
Network summary		1,345	223	15.02	0.00	1.15	....	59	<12

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period. Values of less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

[b] Indicates no report of field estimate received.

[c] Indicates no precipitation sample collected.

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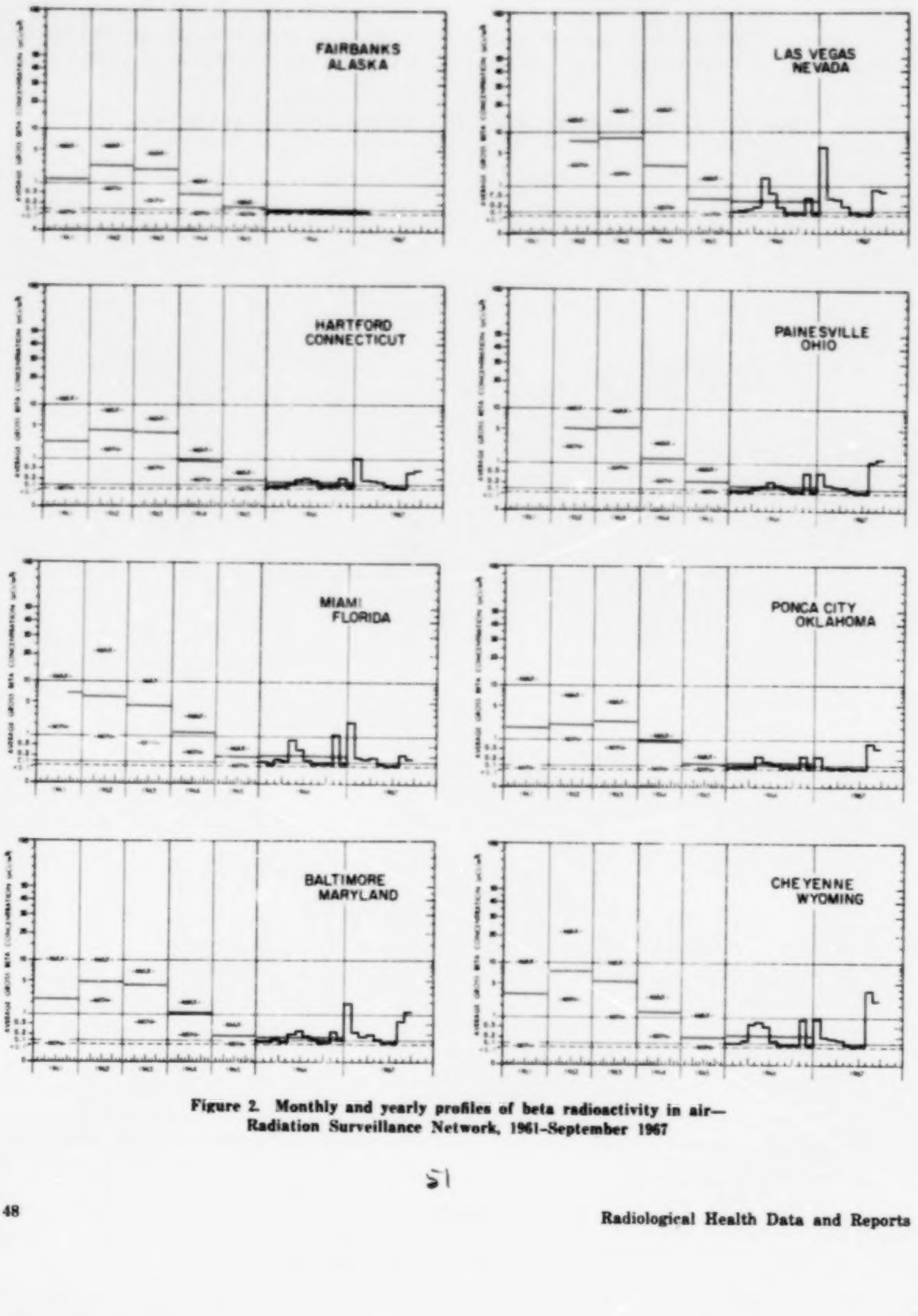

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Surveillance Network, 1961–September 1967

2. Canadian Air and Precipitation Monitoring Program, September 1967

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

A summary of the sampling procedures and methods of analysis was presented in the November 1966 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for September 1967 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, September 1967

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m²)
Calgary	30	0.0	0.0	0.0	(a)	0.3
Coral Harbour	13	.0	.0	.0	17	1.1
Edmonton	30	.0	.0	.0	98	0.3
Ft. Churchill	30	.0	.0	.0	3	0.1
Ft. William	30	6.3	.0	.2	26	0.8
Fredericton	30	1.6	.0	.1	2	0.4
Goose Bay	30	.0	.0	.0	7	0.5
Halifax	30	.0	.0	.0	4	0.5
Inuvik	30	.0	.0	.0	13	0.3
Montreal	30	.0	.0	.0	10	0.5
Moosonee	30	.0	.0	.0	18	0.6
Ottawa	30	4.5	.0	.2	8	1.0
Quebec	30	.0	.0	.0	44	2.9
Regina	30	.0	.0	.0	12	1.0
Resolute	30	.0	.0	.0	NS	NS
St. John's, Nfld	30	.0	.0	.0	14	1.5
Saskatoon	30	.0	.0	.0	20	0.7
Saulte Ste Marie	30	.0	.0	.0	33	1.0
Toronto	30	.0	.0	.0	4	0.2
Vancouver	30	.0	.0	.0	12	0.7
Whitehorse	30	.0	.0	.0	14	0.2
Windsor	30	2.9	.0	.1	40	2.2
Winnipeg	30	1.3	.0	.1	41	0.9
Yellowknife	30	.0	.0	.0	30	0.3
Network summary	703	6.3	0.0	0.0	21	0.8

[a] Trace precipitation.
NS, no sample.

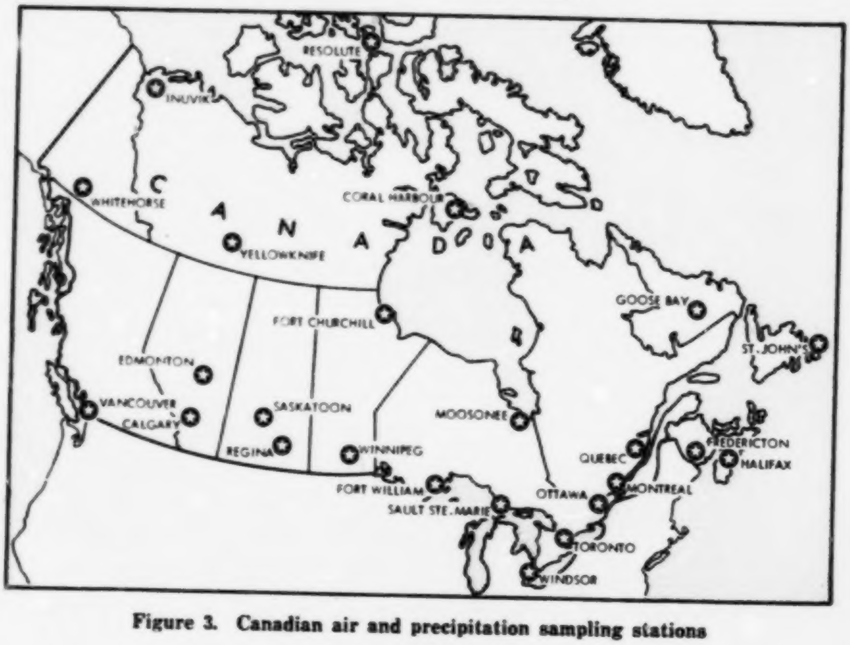

Figure 3. Canadian air and precipitation sampling stations

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[1] Prepared from information and data in the November 1967 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Mexican Air Monitoring Program September 1967

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month were needed to get a reliable average radioactivity at each station (1).

The maximum, minimum, and average beta radioactivity in surface air during September 1967 are presented in table 3.

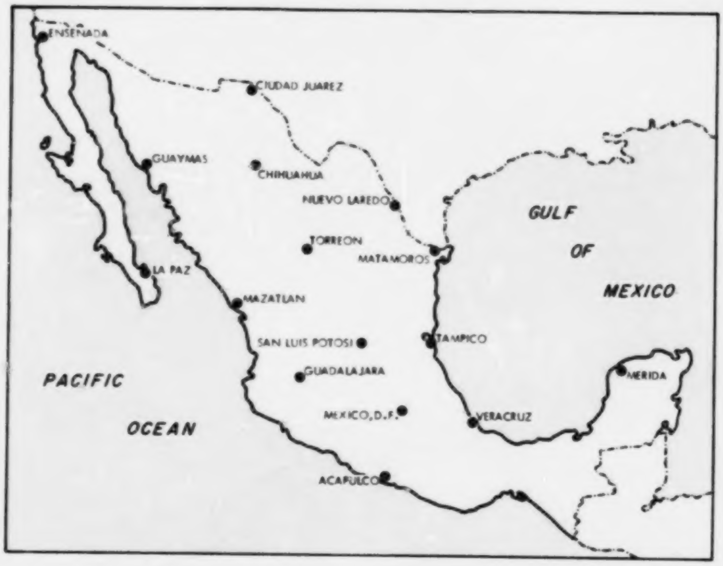

Figure 4. Mexican air sampling locations

Table 3. Mexican gross beta radioactivity of airborne particulates, September 1967

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	16	0.1	<0.1	<0.1
Chihuahua	NS	----------	----------	----------
Ciudad Juárez	NS	----------	----------	----------
Ensenada	11	0.3	<0.1	0.1
Guadalajara	6	0.1	<0.1	<0.1
Guaymas	NS	----------	----------	----------
La Paz	13	0.1	<0.1	0.1
Matamoros	NS	----------	----------	----------
Mazatlán	11	0.1	<0.1	<0.1
Mérida	10	0.1	<0.1	<0.1
México, D. F.	10	0.1	<0.1	<0.1
Nuevo Laredo	NS	----------	----------	----------
San Luis Potosí	NS	----------	----------	----------
Tampico	11	0.4	<0.1	0.1
Torreón	21	0.1	<0.1	0.1
Veracruz	9	0.1	<0.1	<0.1

NS, indicates no sample collected, station temporarily shutdown.

4. Pan American Air Sampling Program September 1967

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the National Center for Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network before July 31, 1967. The air sampling locations are shown in figure 5.

The September 1967 air monitoring results are given in table 4. Airborne gross beta radioactivity levels have decreased since August and are at or near normal at all stations.

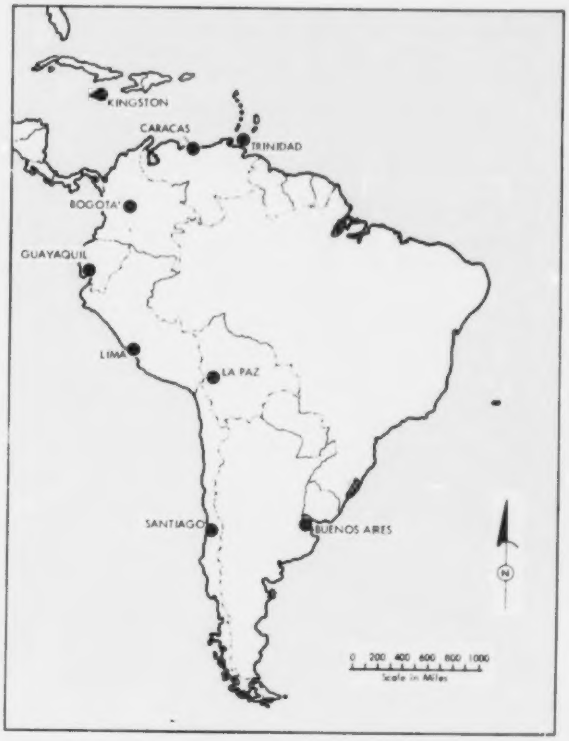

Figure 5. Pan American Air Sampling Program stations

Table 4. PAHO gross beta radioactivity in surface air September 1967

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	9	0.29	0.03	0.12
Bolivia: La Paz	19	.35	.05	.11
Chili: Santiago	28	.34	.05	.12
Colombia: Bogota	21	.09	.00	.02
Ecuador: Guayaquil	30	.19	.03	.09
Jamaica: Kingston	8	.04	.00	.01
Peru: Lima	25	.44	.04	.16
Venezuela: Caracas	19	.10	.01	.03
West Indies: Trinidad	18	.09	.00	.05
Pan American summary	177	0.44	0.00	0.08

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Radionuclides in Alaskan Caribou and Reindeer, March-May 1967

National Center for Radiological Health
U.S. Public Health Service

Under a cooperative agreement between the Alaskan Department of Health and Welfare, the Alaskan Department of Fish and Game, and the U.S. Public Health Service, an active program of caribou and reindeer sampling and analysis was undertaken in 1963 to aid in the assessment of radionuclide intake of Alaskan residents. The basis for this joint sampling activity was a limited sampling effort conducted by these groups in 1962.

Through the second quarter of 1964, the sampling was confined to the three principal caribou herds and one privately owned reindeer herd. This program was expanded in September 1964, when the sampling of additional privately owned and government owned reindeer herds was begun through the assistance of the Fish and Wildlife Service and the Bureau of Indian Affairs, Department of the Interior.

Figure 1 shows the locations of the principal caribou and reindeer herds in Alaska. The code indicates the herds that were sampled during the spring of 1967.

For the present program, samples are taken in the spring and fall from selected caribou and reindeer herds. Muscle and rumen content samples of five separate animals from each herd are collected during the sampling period. Hock joint bones from five animals are collected only from the Nome herd during the fall collection period. Muscle samples are analyzed individually and rumen content samples from each herd are composited before analysis for cesium–137 by gamma-ray spectroscopy. Muscle and bone samples from the individual herd are composited before analysis for strontium–89 and strontium–90. All samples are analyzed at the Public Health Service's Southwestern Radiological Health Laboratory in Las Vegas, Nev.

Strontium–89, strontium–90, and cesium–137 data are presented in table 1 for caribou muscle, reindeer muscle, and rumen contents for the March–May 1967 collection period. The muscle data are of prime interest, since muscle is an important constituent of the diet for many Alaskan residents. A comparison of the muscle data for spring 1966 and spring 1967 is shown in table 2.

The cesium–137 concentrations in the spring of 1967 are quite similar to those found for the spring of 1966 with the exception of the

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Peninsula reindeer herd. The level in 1967 was almost one-third the level in 1966. The reason for this is unknown although the grazing area and diet can vary considerably at different times. A summary of strontium-90 and cesium-137 concentrations in foodstuffs in Alaska (including reindeer and caribou meat) is contained in the December 1966 issue of *Radiological Health Data and Reports.*

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–November 1966	May 1967

NOTE—Correction for Previous Data

During the initial sampling period, analysis of cesium-137 in caribou and reindeer muscle samples from Alaska was performed under non-standard geometry conditions. Since July 1965, a standard procedure has been utilized. Cesium-137 concentrations in samples analyzed with the new procedure were found to be in a range of 1.2 to 1.9 times greater than when the samples were analyzed in a non-standard geometry. Although a correction factor cannot be established for each sample result, this difference should be kept in mind when using analytical results for samples collected and analyzed prior to July 1965, as reported in the December 1964, May 1965, March 1966, and December 1966 issues of *Radiological Health Data and Reports.*

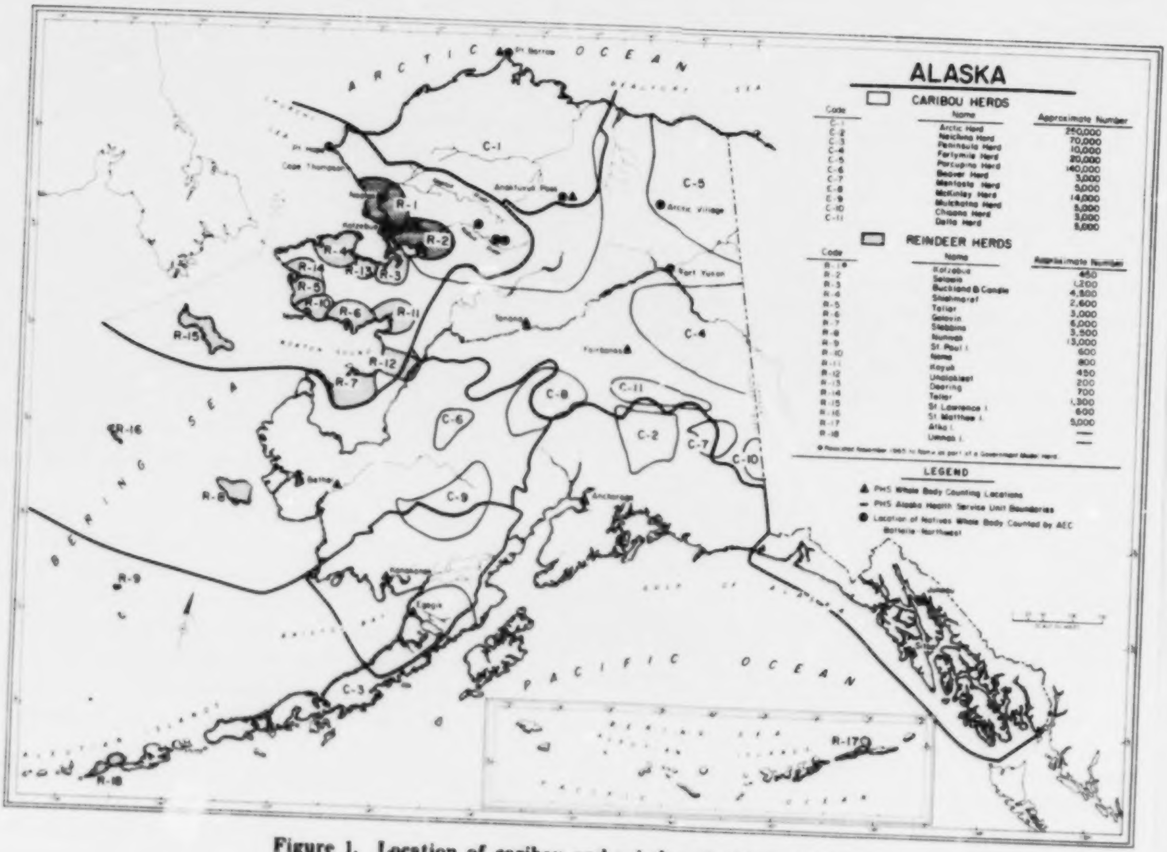

Figure 1. Location of caribou and reindeer herds in Alaska

Table 1. Radionuclide concentration in muscle and rumen of Alaskan caribou and reindeer, March–May 1967

Herd and sampling location [a]	Collection date, 1967	Sex	Age (years)	Muscle (pCi/kg wet weight)			Rumen (pCi/kg wet weight)
				^{89}Sr[b]	^{90}Sr[b]	^{137}Cs	^{137}Cs
Arctic caribou herd Anaktuvuk Pass, C-1	5/4	M	3			24x10^3	19x10^3
	5/6	F	9	8	28	31x10^3	
		F	2			30x10^3	
		F	5			23x10^3	
		F	5			21x10^3	
Nelchina caribou herd Dickey Lake, C-2	3/15	M	4	<5	2	17x10^3	7.1x10^3
	3/16	M	4			12x10^3	
	3/21	M	3			16x10^3	
		F	5			13x10^3	
		F	4			11x10^3	
Peninsula caribou herd King Salmon, C-3	4/15	M	2	<5	2	16x10^3	[illegible]x10^3
		M	3			13x10^3	
	4/16	F	3			18x10^3	
		F	1			14x10^3	
		F	calf			18x10^3	
Shishmaref reindeer herd, Seward Peninsula, R-4	5/1	F	2	<5	16	13x10^3	6.4x10^3
		F	1			19x10^3	
		F	1			16x10^3	
		M	3			20x10^3	
		M	4			15x10^3	
Nunivak Island, reindeer herd, R-8	4/26	M	3	<5	20	27x10^3	9.5x10^3
		F	3			30x10^3	
		F	3			26x10^3	
		F	3			46x10^3	
		M	3			33x10^3	
Nome reindeer herd, R-10	4/8	F	7	<5	34	23x10^3	14x10^3
		F	8			23x10^3	
		M	2			24x10^3	
		M	3			20x10^3	
		M	4			19x10^3	

[a] Sampling locations are shown in figure 1.

[b] Composite of individual samples taken within the herd.

Table 2. Spring cesium-137 concentrations in caribou and reindeer muscle, 1966–1967

Herd	Average cesium-137 concentration (pCi/kg wet weight)	
	Spring 1966	Spring 1967
Arctic caribou	18x10^3	26x10^3
Nelchina caribou	13x10^3	14x10^3
Peninsula caribou	44x10^3	16x10^3
Shismaref reindeer	19x10^3	17x10^3
Nunivak reindeer	33x10^3	32x10^3
Nome reindeer	22x10^3	22x10^3

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Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation protection standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of data from the environmental radioactivity monitoring reports follow for the Paducah Plant, Portsmouth Area Gaseous Diffusion Plant, and the Rocky Flats Plant.

---

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

---

1. Paducah Plant
January–June 1967[2]

Union Carbide Corporation
Paducah, Kentucky

The Paducah Plant is a government-owned gaseous diffusion plant operated by the Nuclear Division of the Union Carbide Corporation for the Atomic Energy Commission. The diffusion plant processes large quantities of relatively pure uranium compounds. The uranium hexafluoride manufacturing plant, a former source of diffusion plant feed, was placed on standby in June of 1964. Parts of the associated uranium metal foundry, usually on standby, were operated during most of this report period. A decontamination and uranium recovery facility operates to prepare equpment for repair and to recover impure or scrap uranium materials. Depleted uranium metal is fabricated into shields, weights, ballasts, or other shapes on a nonroutine basis. The major sources of external penetrating radiation are the daughter products of uranium, thorium–234 and protactinium–234, which may be concentrated by uranium recovery processes or by uranium hexafluoride vaporization. The element uranium can be a physiological hazard only if allowed to enter the body. The chemical toxicity of the uranium processed at the Paducah Plant overshadows any probable biological effects of radiation from this element, thus making it comparable as a physiological hazard to lead, mercury, or other well-known heavy metals.

Because of the necessity for health protection in process areas, the high intrinsic value of uranium, and the desire to maintain a wholesome relationship with neighboring communities and individuals, the Paducah Plant provides confinement and recovery systems at the plant. The environmental monitoring program provides for continuously sampling air at four stations around the plant perimeter fence, and at five stations located approximately 1 mile outside this fence (figure 1). Big Bayou Creek water is sampled continuously, and grab samples are collected at five locations in the Ohio River. In addition, gamma radiation readings are taken each month at each of the air

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[2] Summarized from "Environmental concentrations of radioactive materials near the Paducah Plant—Report for the First Half of 1967."

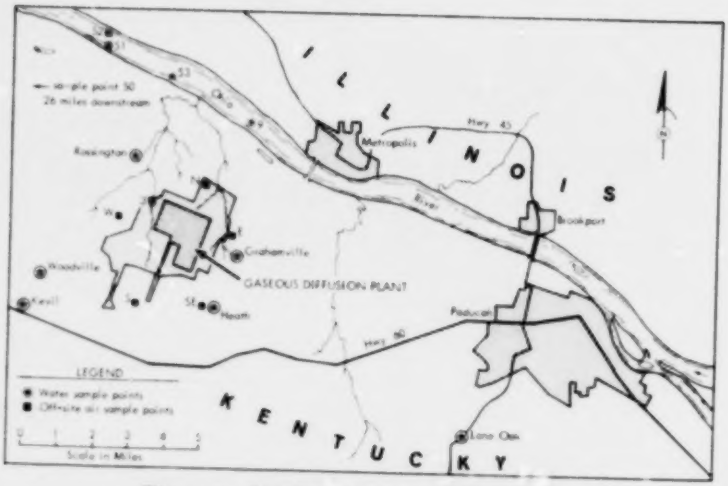

Figure 1. Sampling locations, Paducah Plant

sampling stations with a Geiger-Mueller type meter at a distance of 3 feet above ground level.

Basic standards

The radiation protection standards observed at the Paducah Plant for exposure to radiation and radioactive materials, both for the in-plant work environment of employes and for offsite exposure of the general population, are those contained in Appendix 0524 of the AEC manual.

The standards specify that the radiation or radioactive materials outside a controlled area, and which have resulted from operations within that controlled area, shall be such that it is improbable that any individual may receive a dose of external radiation greater than 0.5 rem in any year and that the average exposure of a suitable population sample may not exceed one-third of this dose. To meet this standard, the average concentration of radioisotopes in air or water beyond a controlled area should not exceed one-tenth of the maximum permitted for occupational exposure of 168 hours per week. For the purposes of such control, the concentrations of such radionuclides in air or water may be averaged over periods of time up to 1 year.

Discussion

Data summarizing the environmental concentrations of radioactive materials in air and water and the gamma radiation levels in the vicinity of the Paducah Gaseous Diffusion Plant are presented in tables 1 through 4.

Air samples were collected continuously at each of the four stations at the plant perimeter fence and at five stations about 1 mile outside the plant. Air is filtered at 0.3 cfm through 2-inch diameter membrane filters which are replaced weekly and counted for alpha and beta radioactivity.

The average alpha-particle count — interpreted as uranium, the most likely source of radioactivity—of the 234 air samples collected during the first half of 1967 were less than 1 percent of the AEC standard set for individuals residing in the vicinity of a controlled area. The mean beta-particle count of the same samples was 0.02 percent of the standard.

The average uranium analysis of weekly water samples collected continuously from the Big Bayou Creek during the first half of 1967 was 0.03 percent of the AEC standard for water beyond a controlled area. The results of the uranium analyses for each of the 6 grab samples collected at monthly intervals from the

Table 1. Uranium concentrations in outdoor air samples, Paducah, January–June 1967

Sample location [a]	Number of samples	Uranium alpha radioactivity [b] (pCi/m^3) Maximum	Minimum [c]	Mean [d]
At plant perimeter fence:				
North	26	0.06	<0.02	<0.02
East	26	.20	< .02	.03
South	26	.03	< .02	< .02
West	26	.02	< .02	< .02
Total, January–June	104	0.20	<0.02	<0.02
About 1 mile outside plant perimeter fence:				
North	26	0.02	<0.02	<0.02
East	26	.02	< .02	< .02
South	26	.06	< .02	< .02
West	26	.02	< .02	< .02
Southeast	26	.02	< .02	< .02
Total, January–June	130	0.06	<0.02	<0.02

[a] See map in figure 1.

[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57 x 10^4 alpha dis/sec.

[c] The minimum detectable concentration of uranium in air is 0.02 pCi/m^3.

[d] The AEC standard for natural uranium in air released to the environs beyond a controlled area is 2 pCi/m^3.

Table 2. Beta radioactivity in outdoor air samples, Paducah, January–June 1967

Sample location [a]	Number of samples	Beta radioactivity (pCi/m^3) Maximum	Minimum [b]	Mean [c]
At plant perimeter fence:				
North	26	1.3	<0.1	0.18
East	26	2.0	< .1	.32
South	26	0.48	< .1	.14
West	26	1.7	< .1	.20
Total, January–June	104	2.0	< .1	0.22
About 1 mile outside plant perimeter fence:				
North	26	1.1	< .1	.19
East	26	0.9	< .1	.18
South	26	2.6	< .1	.25
West	26	0.44	< .1	.10
Southeast	26	4.3	< .1	.29
Total, January–June	130	4.3	<0.1	0.20

[a] See map in figure 1.

[b] The minimum detectable amount of beta-particle emitters in air is 0.1 pCi/m^3.

[c] The AEC standard, applicable to this table is 1 x 10^3 pCi/m^3, which is the concentration limit of thorium-234, the daughter product of uranium-238. Insignificant amounts of other daughters are present in freshly refined uranium.

Table 3. Concentrations of uranium in water, Paducah January–June 1967

Sample location [a]	Number of samples	Uranium concentrations [b] (pCi/liter) Maximum	Minimum [c]	Mean [d]
January–June 1967:				
Big Bayou Creek 3	26	32	<1	5
Ohio River 9	6	2	<1	1
Composite of 50, 51, 52, and 53	6	1	<1	<1

[a] See map in figure 1.

[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57 x 10^4 alpha dis/sec.

[c] The minimum detectable uranium in water is 1 pCi/liter.

[d] The AEC standard for natural uranium in water beyond a controlled area is 2 x 10^4 pCi/liter.

Table 4. Concentration of beta-particle emitters in water, Paducah, January–June 1967

Sample location [a]	Number of samples	Beta-particle emitters (pCi/liter) Maximum	Minimum [b]	Mean [c]
January–June 1967:				
Big Bayou Creek 3	26	500	<100	100
Ohio River 9	6	<100	<100	<100
Composite of 50, 51, 52, and 53	6	<100	<100	<100

[a] See map in figure 1.

[b] The minimum detectable amount of beta-particle emitters in water is 100 pCi/liter.

[c] The AEC standard for the immediate daughter products of uranium in water released to the environs is 2 x 10^4 pCi/liter.

Ohio River below the plant were less than 0.01 percent of the AEC standard.

The concentration of beta-particle emitters in the Big Bayou Creek averaged 0.5 percent of the AEC standard for the decay products of uranium-238 during the first half of 1967. The beta radioactivity of the Ohio River was at or below the minimum detectable level during the first half of 1967, and the results of all samples during the year averaged less than 0.5 percent of the standard for uranium-238 decay products.

External gamma radiation in the vicinity of the Paducah Plant averaged 0.02 mR/hr at all sampling stations for January–June 1967.

Recent coverage in *Radiological Health Data and Reports:*

Period	*Issue*
January–June 1966	January 1967
July–December and calendar year 1966	July 1967

2. Portsmouth Area Gaseous Diffusion Plant [3] January–June 1967

Goodyear Atomic Corporation
Piketon, Ohio

The separation of uranium isotopes by the gaseous diffusion process presents control problems to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium-234 are the most likely radionuclides to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. Since natural uranium is an alpha-particle emitter and thorium-234 is a beta-particle and gamma-ray emitter, environmental monitoring is conducted for evidence of alpha-particle, beta-particle and gamma-ray emitters to test the effectiveness of plant controls.

Air samples are generally collected monthly at 21 sites located from 1 to 6 miles from the plant as shown in figure 2. Monthly water samples are collected at 13 stations within 5 miles of the plant.

For January–June 1967, the waterborne alpha radioactivity, airborne alpha, beta-gamma radioactivity, and the background dose rate remained substantially unchanged compared with the 1966 results. The waterborne beta-gamma radioactivity, however, increased for the first half of 1967. This increase was caused by one sample obtained from a plant effluent stream inside the plant boundaries (the results showed only 6.0 percent of the AEC concentration standards). Samples taken downstream of all plant effluent showed a dilution factor of 17 to 1.

Average background exposure rates remained unchanged from the 1966 values. In the calculations it is assumed that all of the exposure rates are attributable to plant operations. As in the past, the offsite and onsite patterns are very much alike in form and intensity with no significant differences between the average values. From the onsite and offsite intensities and the continuing decline in exposure rates which followed the moratorium in nuclear testing activities, it is evident that the plant operations have not added appreciably to the general background radiation.

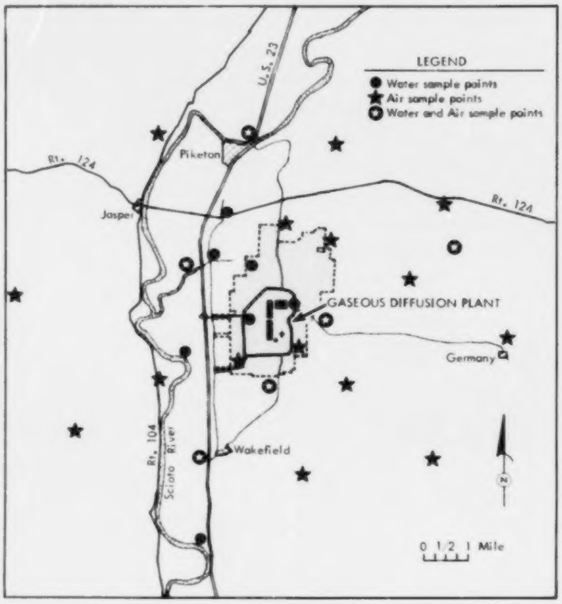

Figure 2. Sampling locations, Portsmouth Area Gaseous Diffusion Plant

Table 5. Environmental radioactivity, Portsmouth Plant January–June 1967

Type of monitoring	Number of samples	Maximum	Minimum	Average	Average as a percent of AEC standard [a]
Air					
Alpha radioactivity (pCi/m^3)	126	0.3	< 0.0	< 0.0	< 5.0
Beta-gamma radioactivity (pCi/m^3)	126	1.7	< .1	< .1	.02
Water					
Alpha radioactivity (pCi/liter)	71	230	< .5	17.5	.09
Beta-gamma radioactivity (pCi/liter)	71	1,170	<14.0	39.7	.20
Background exposure [b] (mrad/hr)	126	.030	.101	.014	17.5

[a] Trace precipitation.

[a] The applicable AEC standards are as follows:

Air (alpha radioactivity)	2 pCi/m^3
Air (beta-gamma radioactivity)	1×10^3 pCi/m^3
Water (alpha radioactivity)	2×10^4 pCi/liter
Water (beta-gamma radioactivity)	2×10^4 pCi/liter
External beta-gamma radioactivity	0.5 rem/yr (approx. 0.06 mrad/hr)

[b] Measurements were made with an open-shield Geiger-Mueller tube 1 foot above ground. The 3-foot rate (not shown) was experimentally determined to average two-thirds of the 1-foot rate and was used to determine the percent of the AEC standard.

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[3] Data summarized from B. Kalman and S. H. Hulett: "Environmental Radiation Levels and Concentrations—First Half 1967," GAT-552 (July 20, 1967).

Average alpha and beta gamma radioactivity concentrations in air and water are summarized in table 5. The external gamma-ray levels, measured at the air sampling locations shown in figure 2, are also summarized in table 5. The overall average concentrations and background exposure rates for 1966 and the first half of 1967 are presented in table 6 as percents of standards.

Recent coverage in *Radiological Health Data and Reports:*

Period	*Issue*
January–June 1966	January 1967
July–December 1966	September 1967

Table 6. Comparison of average concentrations Portsmouth Plant, 1966 and first half 1967

Type of monitoring	Percent of AEC standard [a]			
	1967	1966		
	First half	First half	Second half	Calendar year
Air				
Alpha radioactivity	< 5.0	7.3	< 5.0	1.4
Beta-gamma radioactivity	0.02	0.03	0.01	0.02
Water				
Alpha radioactivity	.09	.07	.09	.09
Beta-gamma radioactivity	.20	.07	.05	.05
Background exposure extrapolated to 3 feet above ground level	17.5	17.7	17.1	17.4

[a] See footnote [a] of table 5.

3. Rocky Flats Plant [1]
January–June 1967

Dow Chemical Company
Golden, Colorado

The Rocky Flats Plant (RFP) is engaged in routine production operations involving plutonium and uranium under contract to the Atomic Energy Commission. Its location relative to population centers is shown in figure 3. To assure properly controlled release of radioactive materials to the environment, periodic samples of air, water, and vegetation are analyzed for gross alpha-radioactivity. The most abundant radioactive material involved in the process is plutonium.

The plant is located about 15 miles northwest of Denver. The surface stratum in this area consists of gravel washed out of the highly mineralized front range of the Rocky Mountains, where heterogeneous low-level deposits of uranium, thorium, and radium exist in the soil. These materials are measurable in most samples of air, water, and vegetation.

Air

Continuous air samples were collected at Coal Creek Canyon, Marshall, Boulder, Lafayette, Broomfield, Wagner School, Golden, Denver, and Westminster. The monthly average long-lived gross alpha radioactivity shown in table 7 are believed to result from naturally occurring materials. All values are less than the AEC standard of 0.04 pCi/m^3 for mixtures of unidentified radionuclides.

Table 7. Long-lived gross alpha radioactivity in airborne particulates, RFP environs, January–June 1967

Period	Average concentration (pCi/m^3)
January	1.0×10^{-2}
February	0.4×10^{-2}
March	0.5×10^{-2}
April	0.7×10^{-2}
May	0.6×10^{-2}
June	0.7×10^{-2}

---

[1] Summarized from "Environmental Survey, January–June 1967," the Dow Chemical Company, Rocky Flats Division, Golden, Colo.

Water

Regular water samples were obtained monthly except during the winter months from four reservoirs in the area of the Rocky Flats Plant. The results of alpha radioactivity analyses performed on these samples are given in table 8. The analytical results for water samples obtained during June from outlying streams and lakes will be presented in the next report. For comparison purposes, the AEC standard for mixtures of unidentified radionuclides in water is 10 pCi/liter.

Table 8. Alpha radioactivity in water, RFP environs January-June 1967

Reservoir	Number of samples	Average alpha radioactivity (pCi/liter)
Great Western	5	2.3
Standley	5	1.0
Baseline	6	1.3
Ralston	6	1.8

Vegetation

During September 1966, 104 samples of vegetation were collected in the vicinity of Rocky Flats Plant at locations up to 18 miles distant from the plant. Gross alpha radioactivity counts were made on the samples. The results are reported in table 9.

Table 9. Alpha radioactivity in vegetation, RFP environs, September 1966

Collection period	Distance from plant	Number of samples	Average concentration (pCi/kg dry weight)
September 1966	Less than 3 miles	60	91
	3 to 18 miles	44	78

Recent coverage in *Radiological Health Data and Reports:*

Period	*Issue*
January–June 1966	December 1966
July–December 1966	May 1967

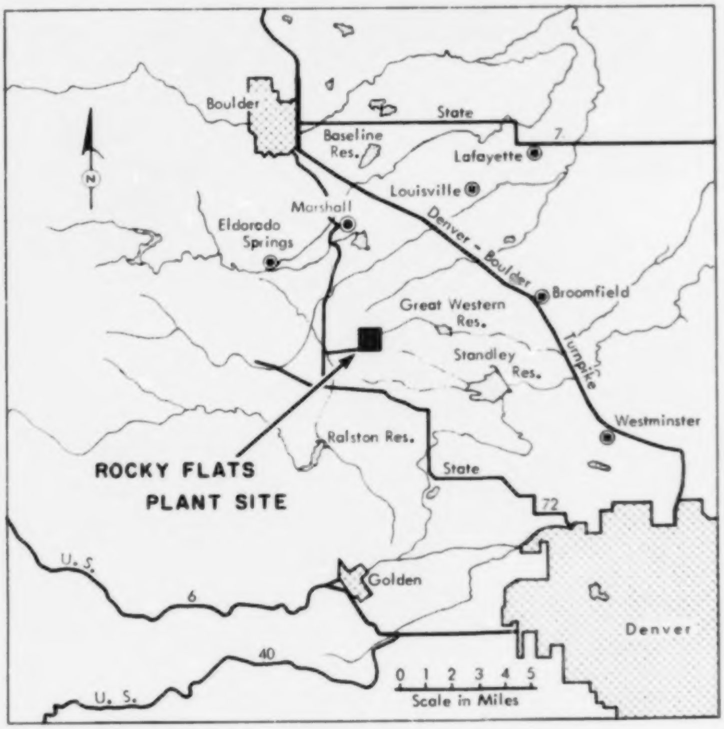

Figure 3. Rocky Flats Plant and environs near Denver, Colorado

Reported Nuclear Detonations, December 1967

The U.S. Atomic Energy Commission detonated a nuclear explosive deep underground in northwestern New Mexico on December 10, 1967, in a natural gas reservoir stimulation experiment called "Project Gasbuggy." The explosive was fired 4,240 feet beneath the surface at 2:30 p.m. Eastern Standard Time some 55 air miles east of Farmington. There was no measurable release of radioactivity and no report of damage from ground shock. Radiation and health safety experts monitored the area as a precaution. Prior to the detonation, pipelines taking gas from wells in the 5-mile radius around the site were visibly cut apart from the El Paso Natural Gas Company System. The nuclear explosive had a designed yield of 26 kilotons. The explosion was designed to create a cavity 160 feet in diameter, which would then collapse, forming a zone or chimney of shattered and broken rock 160 feet in diameter and about 350 feet high. This is more than 3,500 feet underground through the tight gas bearing formation.

On December 15, 1967, the U.S. AEC announced that a nuclear test of low yield (less than 20 kilotons TNT equivalent) was conducted underground at its Nevada Test Site.

On December 24, 1967, the Atomic Energy Commission announced that the U.S. had detected the Seventh Chinese Communist atmospheric nuclear test in the Lop Nor area on December 24, Chinese time. The detonation was in the low yield range.

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

GROSS RADIOACTIVITY OF THE SOLIDS IN SELECTED SURFACE WATERS OF THE UNITED STATES, 1961–1965. *Elmo C. Julian. Radiological Health Data and Reports, Vol. 9, January 1968, pp. 1–16.*

Gross radioactivity has been expressed in pCi/liter of water but to to understand the movement of radiological contamination in the absence of flow data, the consideration of radioactivity in the suspended and dissolved solids in pCi/g is quite useful. The gross radioactivity of the solids in some surface waters of the United States is presented and interpreted in this report with the data from stations of the Water Pollution Surveillance System for the years 1961 through 1965.

Radioactivity levels in surface waters as modified by seasonal runoff patterns are reported. The radioactivity of solids collected below two production reactor facilities was measured and a trend is indicated.

KEY WORDS: Alpha radioactivity, beta radioactivity, fallout, Federal Water Pollution Control Administration, gross radioactivity, natural radioactivity, solids quality, surface waters, water quality.

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RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 9, Number 2, February 1968

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

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Reports

Comparison Of Environmental Radioactivity Levels After Foreign Nuclear Weapons Tests of May 9, 1966, and December 27, 1966

David R. Snavely and *Warren A. Brill*[1]

The environmental radioactivity levels following foreign nuclear weapons tests of May 9, 1966 and December 27, 1966 are compared, and the influence of dairy practices and weather conditions on levels of iodine–131 in milk are discussed. After the former test, the highest monthly deposition by precipitation occurred in the mid-section of the United States south of the Great Lakes (576 nCi/m^2 at Jefferson City, Mo.), and in the northeastern section of Florida. The highest monthly deposition after the latter test occurred along the northern section of the west coast (2,545 nCi/m^2 at Portland, Ore.), northern Utah, the area west of Lake Michigan and in northern Vermont. Following the December test, the highest gross beta radioactivity of surface air particulates (119 pCi/m^3 at Las Vegas, Nev.), the highest gross beta deposition by precipitation, and the highest contribution of nuclides belonging to volatile decay chains (including iodine–131), were found. The highest estimated cumulative iodine–131 intake from drinking 1 liter of milk per day (9,300 pCi/liter) occurred after the May test. This appeared to result from different dairying practices being used at the time of the two tests, and the more rapid elimination of iodine–131 from the cows' feed after the December test.

Two foreign nuclear weapons tests employing fission devices with yields estimated at a few hundred kilotons of TNT were conducted on May 9, 1966 and December 27, 1966, respectively (*1,2*). The latter test was reported to be enriched in nuclides belonging to volatile decay chains (neptunium–239, ruthenium–103, iodine–131 and barium–140) (*3*). The May test took place in the spring when most dairy cows normally are on pasture in the continental United States,[2] while the December test occurred when most dairy cows are not on pasture.

This report compares the environmental radioactivity levels observed in various media following the two reported nuclear weapons tests (*1,2*) and discusses the influence of dairy practices and precipitation on these results.

Data presentation and discussion

Fresh fission products attributable to foreign nuclear weapons tests were first detected on air filters which were removed on the morning of the fifth day after each test from stations located in the northwestern United States. The fresh fission products in surface air moved southward and eastward and covered most of the United States by the tenth day after the tests. Although the yield and the time of arrival of fission debris over the United States were approximately the same for both tests, large differences existed in the radioactivity found in various environmental media and in the relationship between these media.

The highest gross beta radioactivity in surface air particulates at a Radiation Surveillance Network (RSN) station was observed at

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[1] Mr. Snavely is staff officer, Radiological Health Standards Section, and Mr. Brill is staff officer, Radiation Exposure Intelligence Section, both with the Standards and Intelligence Branch, National Center for Radiological Health.

[2] Hawaii and Alaska are excluded in this report.

Phoenix, Ariz. (15 pCi/m^3), 11 days after the May test, and at Las Vegas, Nev. (119 pCi/m^3), 6 days after the December test (*5,6*). The highest monthly gross beta radioactivity deposition from rainfall measured at RSN stations was at Jefferson City, Mo. (576 nCi/m^2) and at Portland, Ore. (2,545 nCi/m^2) for the former and latter tests, respectively. The highest monthly deposition after the May test occurred mainly in the mid-section of the United States south of the Great Lakes and in the northeastern section of Florida (figure 1). The highest monthly deposition after the December test occurred along the northern section of the west coast, northern Utah, the area west of Lake Michigan, and in northern Vermont (figure 2). The monthly gross beta radioactivity depositions for May 1966 and January 1967 were used for comparison purposes because increases were not observed until 4 or 5 days after the tests and continued for approximately 2 weeks. Consequently, increased gross beta radioactivity depositions after the two tests occurred almost exclusively during these intervals.

Air versus precipitation radioactivity concentrations

Moeken and Alderhout derived a relationship between air concentrations and deposition by precipitation (*7*). A similar analysis was made utilizing the principles of Moeken and Alderhout to see if a correlation existed between the product of the gross beta radioactivity measured in air and inches of rainfall with gross beta radioactivity deposition on land for either test.

The data were grouped by the nine Department of Health, Education, and Welfare administrative regions (figure 3). Data for New Orleans, La. were grouped with Region IV. Precipitation data were obtained from the daily weather maps prepared by the U.S. Weather Bureau for the periods May 8 to June 4, 1966 and January 1 to January 28, 1967 (*8*). Environmental radioactivity data were obtained

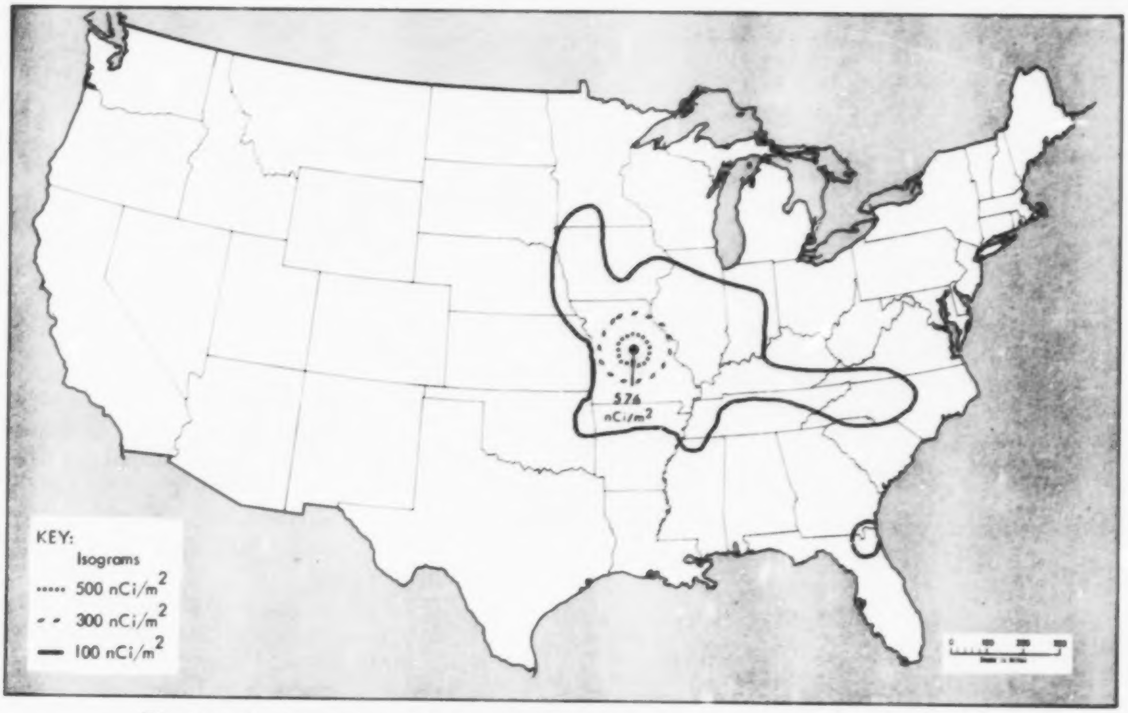

Figure 1. Isograms of gross beta radioactivity deposition during May 1966, estimated from gross beta radioactivity deposition measured at RSN stations

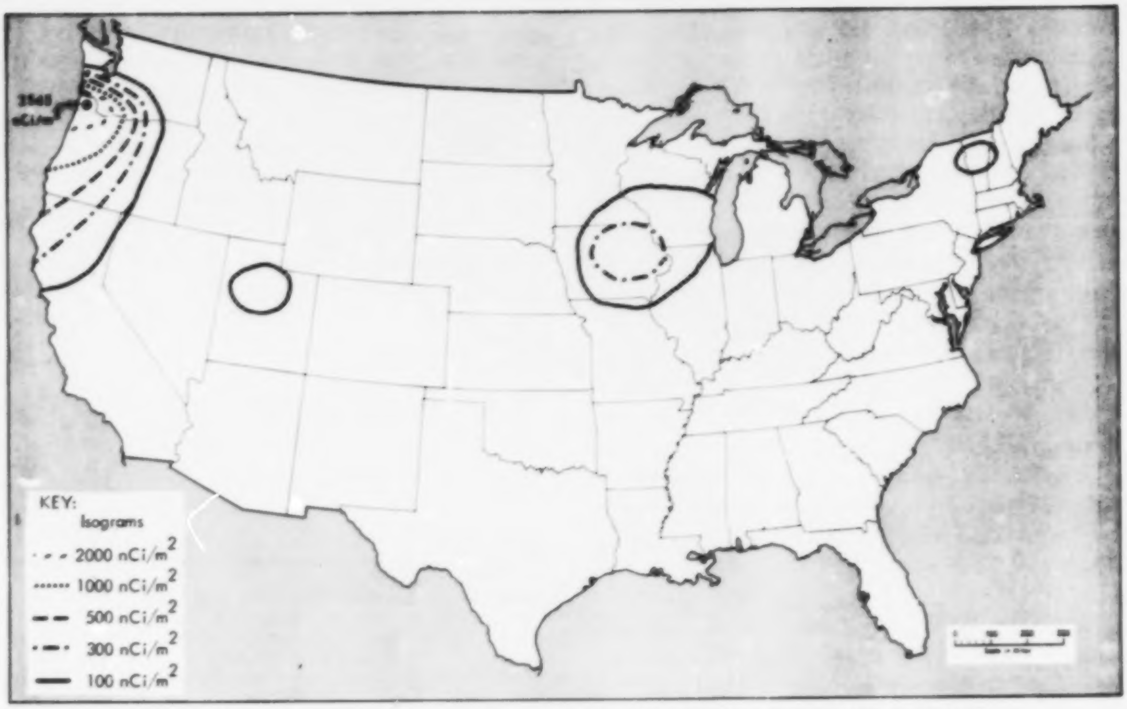

Figure 2. Isograms of gross beta radioactivity deposition during January 1967, estimated from gross beta radioactivity deposition measured at RSN stations

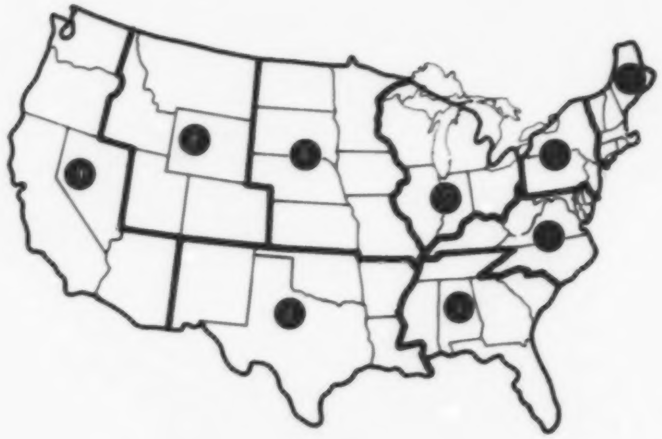

Figure 3. Department of Health, Education, and Welfare administrative regions

from the RSN under the direction of the Environmental Surveillance and Control Program (ESCP) of the National Center for Radiological Health for the same calendar period (9).

For the purpose of data analysis, it was assumed that the average precipitation in a region for any given week fell on the entire region. Also, the deposition of gross beta radioactivity was assumed to have fallen over the entire region and was averaged over the region for the 4 weeks following the tests. Radioactivity from particulates in air for a region was determined by averaging the total amount of radioactivity on air filters by the number of samples taken during the week.

The data for each test were then plotted by region on log-log paper for each week following the tests. The results are shown in figures 4 and 5 for these tests, and it is apparent that there is very little correlation.

Discrepancies arising from this type of data analysis may be due to (a) non-uniform precipitation, hence non-uniform deposition in a region; (b) difference in distribution of fission products in the atmosphere with each pass over the country; (c) decay of short-lived products with time, resulting in less radioactivity depositing or fractionation of the measured radioactivity; and (d) samples assayed near the limit of detectability may have introduced unknown errors.

This precludes any relationship between gross beta radioactivity in air and gross beta radioactivity in deposition, except in very general terms.

Pasture half-times[1] of iodine–131

Table 1 lists pasture half-times of iodine-131 which best fit the milk data for the milk sampling stations and the cumulative iodine–

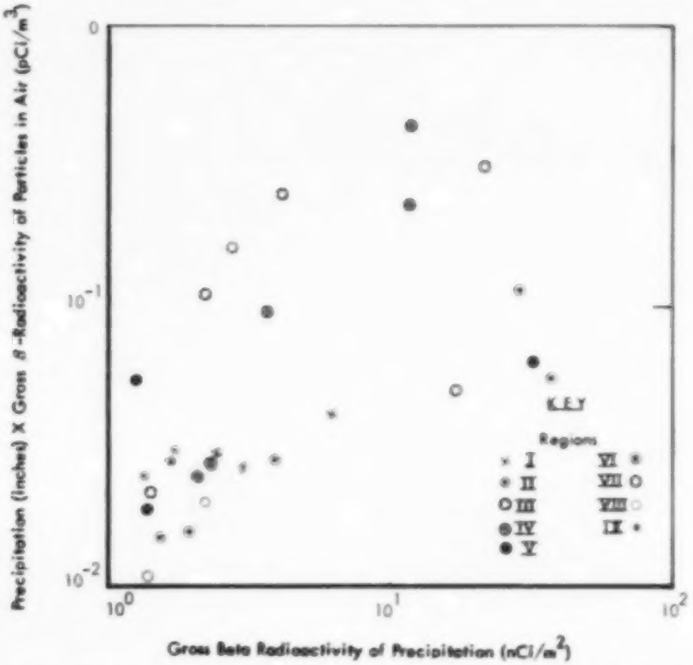

Figure 4. Correlation between average gross beta air radioactivity times average inches of precipitation versus average gross beta radioactivity deposition through rain for the period, May 8-June 4, 1966

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[1] "Pasture half-times" as used in this paper, represents the effective reduction with time of iodine–131 intake of the cow. This will be equal to the actual pasture half-times only if the cow is getting a constant amount of its food from pasture each day; inhalation of iodine–131 can be neglected and it is assumed that other food sources of the cow are not contaminated with iodine–131.

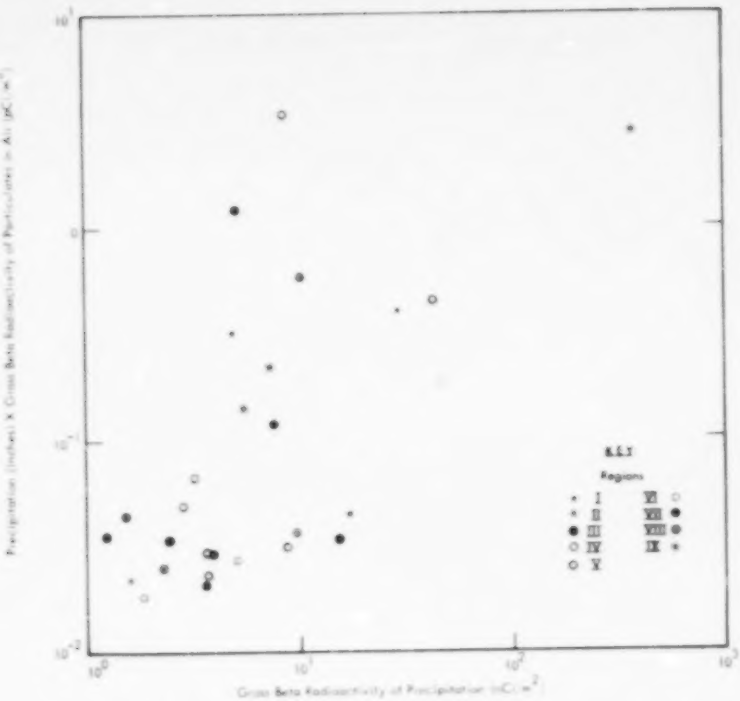

Figure 5. Correlation between average gross beta air radioactivity times average inches of precipitation versus average gross beta radioactivity deposition through rain for the period, January 1-28, 1967

131 intake, assuming milk consumption of 1 liter per day. The results of the May 9, 1966 test and the method of obtaining the pasture half-times and cumulative iodine-131 intake have been described previously (*10*). The criteria for determining these values are:

1. at least one sample from the sampling station site has a milk concentration of iodine-131 of 50 pCi/liter or greater,
2. samples were collected at least once a week at the sampling site,
3. the second milk sample from a sampling site was collected within 3 days of the collection date of the first milk sample with detectable iodine-131 (>10 pCi/liter); or the iodine-131 concentrations of the first milk sample was less than the iodine-131 concentration of the second sample,
4. collection from a sampling site was continued until iodine-131 concentrations in milk were below detectable levels.

The milk sampling frequency was less than that required by criterion (*3*) for the December test for most stations. Only ranges of cumulative iodine-131 intakes could be given. In addition, the two California State sampling locations did not meet criterion (*4*), although the iodine-131 concentrations were near detectable limits for the last samples reported.

Table 1 shows that the pasture half-times were generally longer for the May test than for the December test. The sampling frequency mode was 9 days for the May test and 4 days for the December test. The lowest pasture half-times for the May test was 4 days compared to 1 day for the December test. The short pasture half-time of 1 day indicates that the iodine-131 intake was for a brief period of time (1 to 2 days). Dry lot feedings (if the feed is spread out each day) and a deposition time of only 1 or 2 days would account for a short iodine-131 intake period. This explanation is plausible

Table 1. Pasture half-times and estimated human iodine–131 cummulative intakes from drinking milk after foreign nuclear tests of May 9, 1966, and December 27, 1966

Sampling location		Sample origin [a]	Pasture half-times (days)		Cummulative iodine-131 intakes [b] (pCi)	
			May test	December test	May test	December test
Ala:	Montgomery	P	9	4	870	920-1,200
Ark:	Little Rock	P	4	—	5,800	....
	Green County	S	4	—	6,000	....
	Lonoke County	S	4	—	5,000	....
	Miller County	S	4	—	1,500	....
	Ouachita County	S	4	—	1,900	....
	Sebastian County	S	4	—	9,300	....
	Washington County	S	4	—	6,500	....
Calif:	Del Norte County	S	—	3		2,600
	Humbolt County	S	—	3		2,200
Ga:	Atlanta	P	9	4	980	920-1,100
Ind:	Indianapolis	P	5	—	2,200	....
	Fort Wagner	S	9	—	1,400	....
	Indianapolis	S	9	—	2,100	....
	Rochester	S	8	—	3,100	....
Iowa:	Des Moines	P	9	—	1,100	....
Kans:	Wichita	P	9	—	1,900	....
Minn:	Minneapolis	P	4	—	810	....
Miss:	Jackson	P	58	—	920	....
Mo:	Kansas City	P	9	—	2,200	....
	St. Louis	P	9	—	3,800	....
Nebr:	Omaha	P	9	—	1,600	....
N. C:	Charlotte	P	58	—	1,300	....
Ohio:	Cincinnati	P	8	—	760	....
Okla:	Oklahoma City	P	9	—	2,200	....
	Enid	S	9	—	1,200	....
	Lawton	S	9	—	1,300	....
Ore:	Portland	P	—	8		820-1,000
	Redmond	S	—	1		[d]310
S. C:	Charleston	P	9	3	1,200	1,300-3,600
Tenn:	Memphis	P	9	—	1,400	....
Tex:	Austin	P	9	5	620	1,200-1,400
	Dallas	P	9	5	1,200	750-1,100
	Lubbock County	S	9	—	1,100	....
	Austin	S	—	4		1,000-1,500
	Houston	S	—	4		[e]2,900-4,500
Utah:	Salt Lake City	S	—	1		170
	South Utah County	S	—	1		370

[a] P—PMN sample.
S—State sample.
[b] One liter/day consumption rate assumed.
[c] Dash indicates no sample.
[d] Start of iodine-131 cow intake was assumed to have occurred January 1.
[e] Start of iodine-131 cow intake was assumed to have occurred after December 31.

since the majority of the gross beta radioactivity deposition measured at the Portland, Ore. RSN station occurred during January 1 and 2, and cattle in the Portland coastal region and in Humbolt and Del Norte counties of California were receiving only 10 percent of feed value from pasture. If the other 90 percent of the feed value was received through feed put out each day, the cows would have ingested iodine–131 deposited on stored feed placed outside on January 1 and 2 (the days when most of the gross beta radioactivity deposition occurred at Portland).

Estimates of iodine–131 intake versus deposition

All sampling locations of the PHS Pasteurized Milk Network (PMN) and those reported by the States are shown in figures 6 and 7. Sampling locations where iodine–131 was detected are indicated on these figures. Concentrations of 20 pCi/liter or greater was taken as the minimum detection limit for this study, except for Idaho (50 pCi/liter minimum detection limit) and Vermont (80 pCi/liter minimum detection limit). Total intake isograms of the cumulative iodine–131 intakes were drawn from the values and sampling locations given in table 1. All samples collected outside the 1,000 pCi isogram line had iodine–131 concentrations of 60 pCi/liter or less. Exceptions were: figure 6—several samples collected in Utah where the highest sample was reported as 270 pCi/liter; figure 7—two samples from Alabama, one sample from North Dakota, one sample from Tennessee, and three from Utah which were all below 125 pCi/liter.

Milk samples collected at PMN stations represent a composite of the milk sold in the area. As the PMN samples generally are representative of the milk produced over large areas rather than small areas, they do not serve to

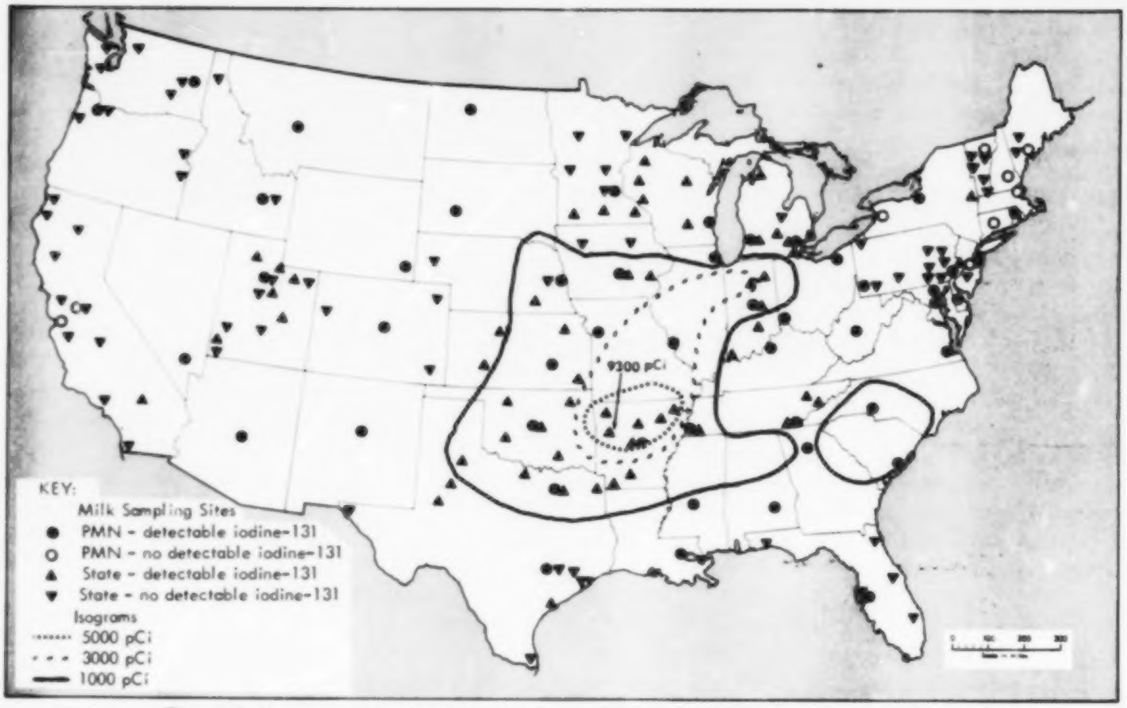
9300 pCi
KEY:
Milk Sampling Sites
● PMN - detectable iodine-131
○ PMN - no detectable iodine-131
▲ State - detectable iodine-131
▼ State - no detectable iodine-131
Isograms
······ 5000 pCi
- - - 3000 pCi
—— 1000 pCi

Figure 6. Isograms of estimated iodine-131 intake from drinking 1 liter of milk per day following the nuclear weapons test of May 9, 1966

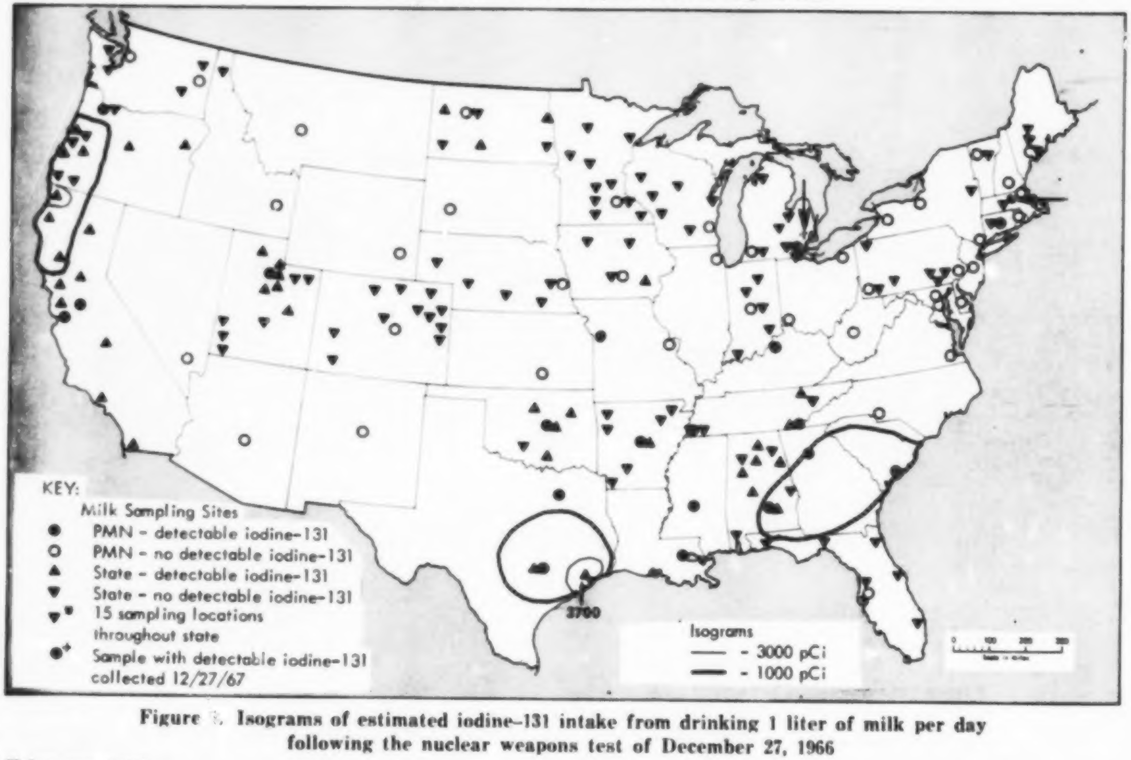
3700
KEY:
Milk Sampling Sites
● PMN - detectable iodine-131
○ PMN - no detectable iodine-131
▲ State - detectable iodine-131
▼ State - no detectable iodine-131
▼* 15 sampling locations throughout state
●+ Sample with detectable iodine-131 collected 12/27/67
Isograms
—— - 3000 pCi
—— - 1000 pCi

Figure 8. Isograms of estimated iodine-131 intake from drinking 1 liter of milk per day following the nuclear weapons test of December 27, 1966

delineate in as much detail those areas where iodine–131 concentrations are high in milk. The milk samples collected by the States usually are representative of milk produced in areas of smaller size than are PMN samples. Hence, State milk samples define in more detail high or low regions of iodine–131 in milk. When available, the State data were used to draw isograms, rather than the PHS results. The isograms of estimated cumulative iodine–131 intake after the May test roughly correspond to the area which had the greatest gross beta radioactivity deposition (figures 1 and 6).

When figures 2 and 7 are compared, the estimated iodine–131 intake isograms for the December test correspond to the deposition isograms only in the northwestern coastal area. A partial explanation for this can be obtained from figure 8 which gives some indication of pasture conditions after this test. Except for the West Coast, southern Arizona and New Mexico, Texas, Oklahoma, the Southeast extending north to parts of Missouri, Illinois, Indiana, Ohio, West Virginia, and Virginia, pastures were covered with snow (*11*). Olsen has reported the approximate dates cattle are on pasture (4). Only cattle in the Deep South and in California would be expected to be on pasture (figure 8) during an average winter. With the exception of the Oregon coast, these were the locations where the highest intakes of iodine–131 were determined.

Comparisons were made of the areas within the 1,000 pCi iodine–131 intake isograms following the two tests. The northwestern Oregon area, following the December test, had higher gross beta radioactivity deposition than the Missouri-Arkansas area following the May test, but had lower iodine–131 intake estimates (suggesting that cows were receiving less of their food from pasture). However, the southeastern Texas and South Carolina-Georgia-Alabama areas had iodine–131 intake estimates as high or higher than in the Oregon area following the December test even though the deposition was below 100 nCi/m^2. Areas having depositions of 100 nCi/m^2 or greater following the May test showed iodine–131 intakes similar to or higher than iodine–131 intake in Oregon following the December test. Areas with

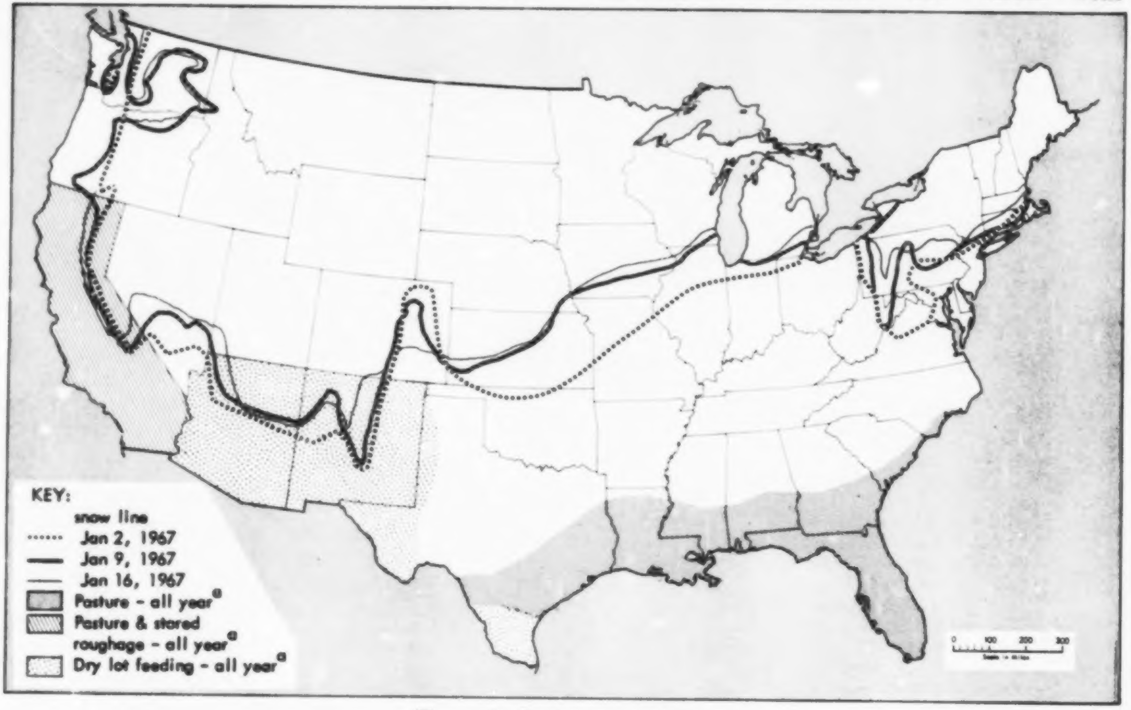

Figure 8. Pasture conditions

iodine–131 intakes following the December test similar to that in Oregon had gross beta radioactivity deposition less than 100 nCi/m². A possible reason for these results would be a slower pasture growth requiring the cows to graze a larger area, and thus increase their daily iodine–131 intake.

Summary and conclusions

The highest gross beta radioactivity of surface air particulates, the highest gross beta deposition by precipitation, and the highest contribution of nuclides belonging to volatile decay chains (including iodine–131) were found after the December 27, 1966, foreign nuclear weapons test. The highest cumulative iodine–131 intakes from drinking 1 liter of milk per day were estimated to be for the time period after the May 9, 1966, foreign nuclear weapons test. This is considered to result, in part, from the inferred different dairying practices after the two tests. After the May test, presumably all the cows with the exception of those in dry lot feeding areas were out on pasture. After the December test only those in the Deep South and in California were presumed to be on pasture. Another contributing factor was the more rapid elimination of iodine–131 from the cows' feed, which is indicated by the shorter pasture half-time found during the December test. This again points to differences in dairying practices or weather conditions or a combination of both and points out the importance of considering dairying practices when attempting to predict the amount of iodine–131 expected in milk as a function of deposition.

Acknowledgment

The authors wish to express their appreciation for the assistance received from the State personnel represented by the programs mentioned herein, without whose assistance this report would not have been possible.

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Technical Notes

Offsite Environmental Surveillance Findings Associated With Underground Nuclear Testing; Project Dribble

Hubert D. Harvey, Jr. and *Melvin W. Carter*[1]

Two detonations, termed the Salmon event and the Sterling event, Project Dribble, took place on October 22, 1964, and December 3, 1966, respectively. These detonations were a part of the Department of Defense (DOD)—Atomic Energy Commission's (AEC) seismic research program called Vela Uniform, which is designed to improve U.S. capabilities to detect, identify, and locate underground nuclear detonations.

Both events took place approximately 2,720 feet underground in a salt formation known as the Tatum Salt Dome, 19 air miles southwest of Hattiesburg, Miss. The Salmon shot was a 5-kiloton nuclear detonation in a tamped emplacement (one in which the shot chamber is as small as possible). The Sterling shot was a decoupled detonation (fired in the center of a cavity to study the reduction of ground shock and long-range seismic signal transmission) of a nuclear device of approximately 350 tons, conducted in the 110-foot diameter, roughly spherical cavity formed by the Salmon shot. The location of the test site is shown in figure 1.

The offsite program was conducted by the National Center for Radiological Health (NCRH) staff consisting of personnel from the regional laboratories (Southeastern Radiological Health Laboratory, Southwestern Radiological Health Laboratory, and Northeastern Radiological Health Laboratory), and PHS reserve officers recruited for temporary duty. In addition, a medical officer and a veterinary officer were on full-time duty in Hattiesburg. The operations included environmental sampling and analysis and ground and aerial monitoring. Also, because the program was conducted in a populous area, and involved the temporary evacuation of offsite residents of the immediate vicinity, a personalized public relations program constituted an important feature of the program.

A description of the organization of the operation and of the procedures in support of the Salmon event has been published (*1*). The same general procedures were followed for the Sterling event.

An environmental sampling program was initiated during April and May 1963 for the collection of background radiation data. Milk, water, vegetation, and air were sampled routinely before and after the shots. The types of sampling done are shown in figure 2.

Procedure

In order to meet any possible emergency associated with contamination of milk in the offsite area, surveys were conducted in coordination with the State Health Departments of Mississippi and Louisiana. Data were assembled concerning approximately 1,600 dairy farms, 30 milk processing plants, and details concerning bulk-truck collections. The information gathered was utilized to establish a composite milk sampling program within a 50-mile radius of the test site. Sampling stations for 12 milk routes, representing 219 dairy farms, were established.

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[1] Mr. Harvey is chief, Engineering Services, SERHL; and Dr. Carter is director, Southeastern Radiological Health Laboratory, Montgomery, Ala.

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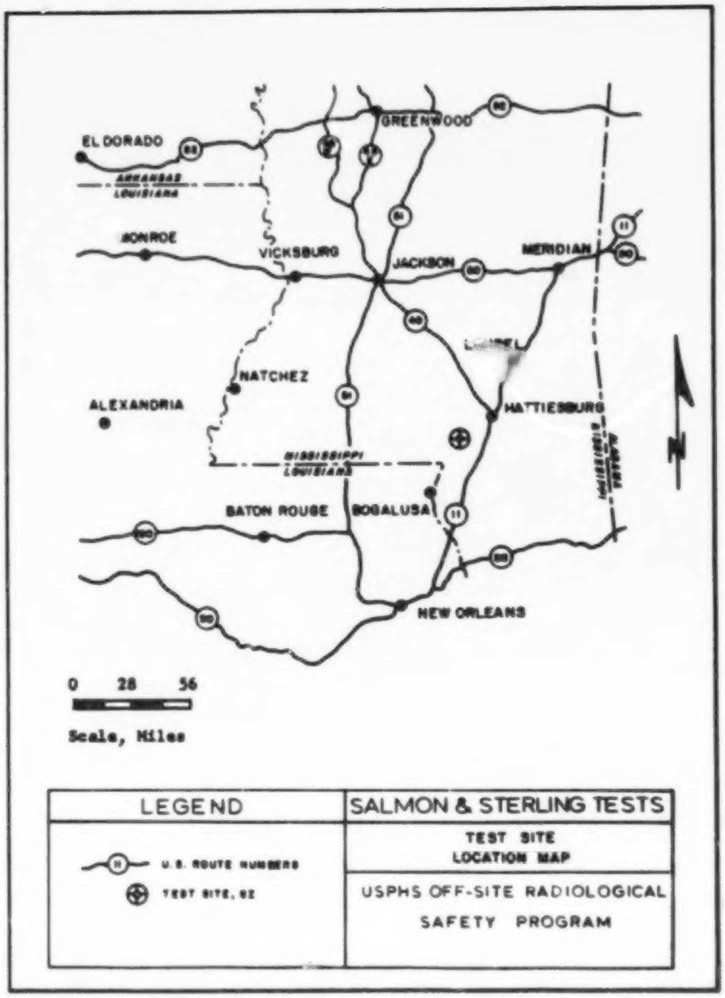

Figure 1. Test site location map

The environmental sampling program, initiated in May 1963, in preparation for the Salmon event, included air, milk, water, vegetation, and other selected media. The samples were representative of an area bounded by a 50-mile radius of the test site. This coverage would be supplemented with mobile sampling capacity at shot time.

As nearly as possible, the collection of routine samples was coordinated with local residents; that is, offsite residents were recruited to operate permanent air sampling stations, and in certain instances, to assist in the collection of milk and water samples.

The environmental sampling coverage which was established prior to the Salmon shot is shown in figure 2 and tabulated below. The film badge coverage and locations of background recorders are also shown in figure 2.

The sampling program for the Sterling event was essentially the same as for Salmon with the exception that 10 less water stations and 13 less one-cow-family type milk stations were in operation for Sterling than for Salmon. Also, fewer personal film badges were distributed for Sterling than for Salmon. These small differences in environmental coverage were associated with (1) the differences in the predic-

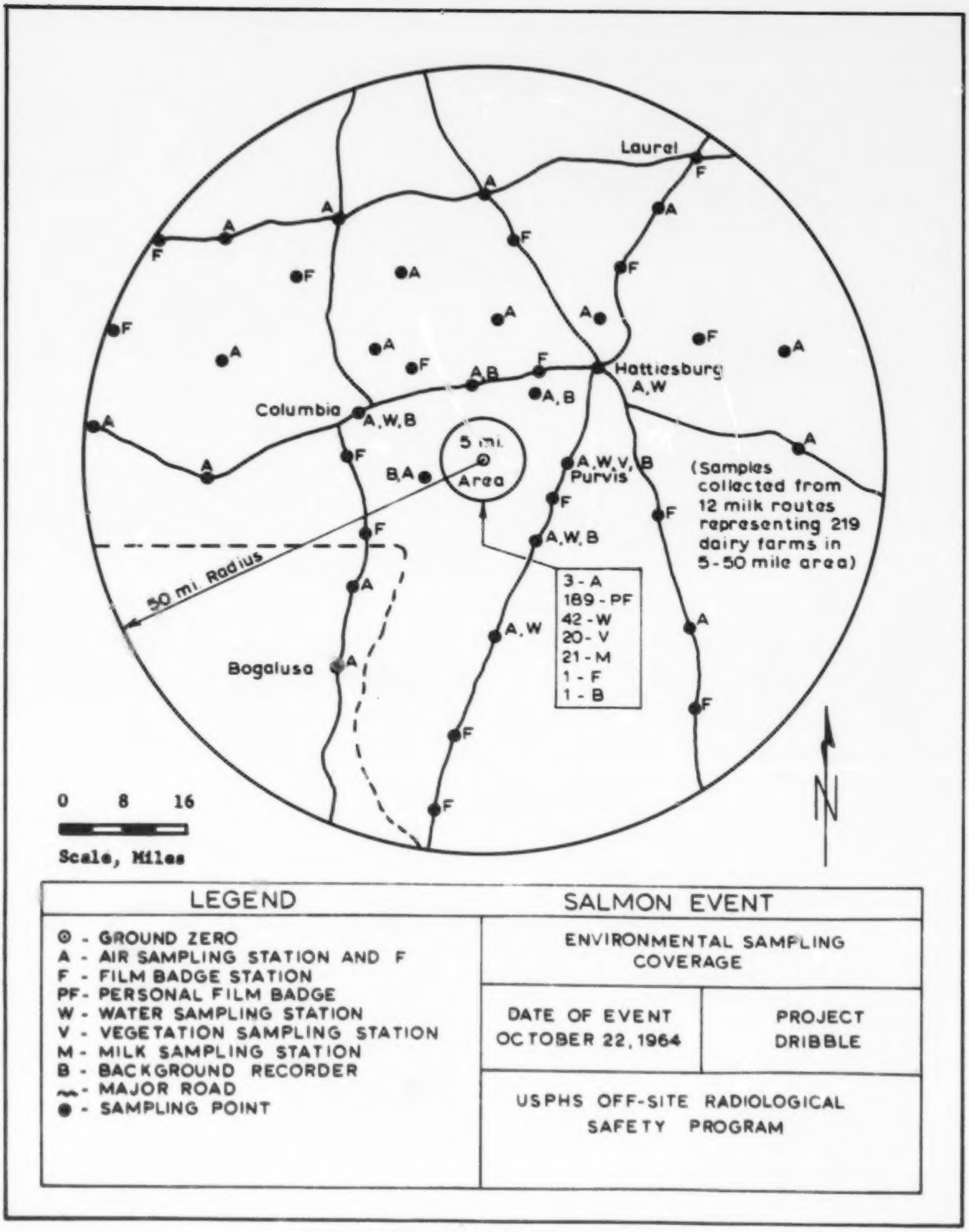
Laurel
Hattiesburg
A,W
Columbia
A,W,B
5 mi.
Area
B,A
A,B
A,W,V,B
Purvis
A,W,B
A,W
Bogalusa
50 mi. Radius
(Samples collected from 12 milk routes representing 219 dairy farms in 5-50 mile area)
3 - A
189 - PF
42 - W
20 - V
21 - M
1 - F
1 - B
A
F
0
8
16
Scale, Miles
N
LEGEND
⊙ - GROUND ZERO
A - AIR SAMPLING STATION AND F
F - FILM BADGE STATION
PF - PERSONAL FILM BADGE
W - WATER SAMPLING STATION
V - VEGETATION SAMPLING STATION
M - MILK SAMPLING STATION
B - BACKGROUND RECORDER
~ - MAJOR ROAD
● - SAMPLING POINT
SALMON EVENT
ENVIRONMENTAL SAMPLING COVERAGE
DATE OF EVENT OCTOBER 22, 1964
PROJECT DRIBBLE
USPHS OFF-SITE RADIOLOGICAL SAFETY PROGRAM

Figure 2. Environmental sampling coverage

tions for a maximum credible accident for the two events, and (2) availability of samples. It was predicted that the area of interest, as associated with possible radiation levels, would be greater for Salmon than for Sterling if an accident occurred, although generally similar coverage was required for both events as a precautionary measure. Also, the availability of samples, especially one-cow-type samples within a 5-mile radius was not the same for Sterling as for Salmon, *i.e.*, fewer cows were being milked at this particular time.

Type of sample	Number of stations
Air	27
Milk	21 (1-2 cows) 12 milk routes (composite samples)
Water	47
Vegetation	21

A counting laboratory was established in Hattiesburg prior to each event for possible use in an emergency. The routine samples which were collected for background purposes were analyzed at the Southeastern Radiological Health Laboratory, Montgomery, Ala., and reports issued on a monthly basis. Special samples collected at shot time were counted at the Hattiesburg laboratory, the facilities of which included analytical capability for alpha, beta, and gamma radioactivity determinations.

In addition to the laboratory in Hattiesburg, a mobile laboratory was utilized for the Salmon event. This laboratory had facilities to analyze samples for alpha, beta, and specific gamma radioactivity and it could be moved easily from one location to another.

The results of analyses of special milk samples collected during Salmon from October 21 to November 6, 1964, from noncommercial sources within a 5-mile radius of the test site are shown in table 1. Small concentrations of iodine–131 were detected in vegetation samples and gross beta concentrations in air particulate samples increased slightly during this period. This rise in activity is attributed to the generalized atmospheric fallout associated with the foreign atmospheric nuclear test of October 16, 1964. A comparison of Radiation Surveillance Network (RSN) air sampling data with the

Table 1. Salmon event, milk data,[a] (October 21–November 6, 1964)

Collection date (1964)	Radioactivity		
	Iodine-131 [b] (pCi/liter)	Cesium-137 (pCi/liter)	Potassium (g/liter)
10-21-64	<10 [c]	70	1.42
10-23-64	<10 [c]	165	1.80
	<10 [c]	120	1.28
	<10 [c]	65	1.03
	<10 [c]	100	1.69
	<10 [c]	75	1.63
10-26-64	<10	220	1.33
	<10	85	1.44
	<10	40	1.79
	<10	55	1.75
	15	160	1.39
	<10	80	1.45
	<10	180	1.87
	<10	100	1.58
	17	60	.86
	<10	70	1.40
10-27-64	35	55	1.32
	20	195	1.66
	<10	50	1.75
	<10	105	1.36
	19	125	1.62
	<10	80	1.58
11-5-64	49	65	1.64
	49	280	1.67
	54	75	1.01
11-6-64	47	200	1.20
	78	255	1.72
	26	70	1.67

[a] Refer to table 4 for explanation of analytical errors.
[b] Corrected for decay to date of collection.
[c] These samples were counted 11 to 13 days after collection. Therefore, the limit of detection for iodine-131 in reference to the date of collection will be approximately 30 pCi/liter.

Table 2. Salmon event, composite milk sample data[a]

Sample collection date	Average radioactivity	
	Cesium-137 (pCi/liter)	Strontium-90 (pCi/liter)
1963		
May	160	18
June	170	21
July	165	17
August	155	17
September	125	16
October	125	17
November	125	18
December	130	18
1964		
January	150	18
February	160	19
March	200	26
April	195	27
May	165	26
June	120	21
July	110	21
August	100	18
September	90	18
October	80	17
November	70	15
December	70	17
1965		
January	65	17
February	75	17
March	90	17

[a] Refer to table 4 for explanation of analytical errors.

offsite surveillance data collected during the Salmon event is discussed later in this report.

The average background concentrations of strontium–90 and cesium–137 (at the time of count) in composite milk samples are shown by month in table 2. These samples were collected from April 1963 to March 1965 in relation to activities associated with Salmon, including post-shot activities. The number of samples submitted monthly ranged from 14 to 28, representing a maximum of 219 dairy farms within a 50-mile radius of the test site. In addition to cesium–137 and strontium–90, iodine–131, strontium–89, and barium–140 were detected in milk samples during this period of time.

The milk data for Sterling are shown in table 3. These data represent composite, commercial and noncommercial-type samples collected in November and December 1966 before and after the shot. The composite samples represent 220 dairy farms within a 50-mile radius of the test site; whereas the noncommercial samples were collected within a 5-mile radius of the site. The individual composite sample data represent, with a few exceptions, the same dairy farms for which average concentrations per sample are shown in table 2. The noncommercial samples were taken from certain of the same locations as were the samples for which data are given in table 1. The major difference in the milk sampling program for the Sterling

Table 3. Sterling event—results of milk analyses[a]

Collection date (1966)	Concentration				
	Potassium (g/liter)	Strontium-90 (pCi/liter)	Iodine-131 [b] (pCi/liter)	Cesium-137 (pCi/liter)	Barium-140 [b] (pCi/liter)
11/23	1.60	10	<10	25	<10
11/24	1.58	18	<10	15	<10
11/25	1.47	22	<10	15	<10
	1.57	34	10	25	<10
	1.57	19	<10	15	<10
	1.46	27	<10	30	<10
	1.44	32	10	15	10
	1.37	20	<10	15	10
	1.57	15	<10	20	<10
	1.49	16	<10	20	10
	1.57	14	<10	25	<10
	1.37	11	<10	25	<10
	1.55	32	10	15	10
11/26	1.47	27	<10	25	<10
	1.44	27	<10	40	<10
	1.58	21	<10	35	<10
11/27	1.47	21	<10	25	<10
11/28	1.64	8	<10	30	<10
11/30	1.52	112	<10	35	<10
	1.20	41	20	25	<10
	1.55	13	<10	25	<10
	1.88	108	20	85	20
	1.64	12	<10	45	<10
	1.40	14	30	30	20
	1.15	62	<10	65	10
12/12	1.54	22	<10	15	<10
	1.38	26	<10	15	<10
12/13	1.47	22	<10	20	<10
	1.47	24	<10	30	<10
	1.41	29	<10	25	<10
	1.48	30	<10	20	<10
	1.43	23	<10	15	<10
	1.46	20	<10	25	<10
	1.58	22	<10	10	<10
	1.50	20	<10	15	<10
	1.48	25	<10	25	<10
12/14	1.51	18	<10	15	<10
	1.45	17	<10	20	<10
	1.56	23	<10	25	<10
	1.47	29	<10	15	<10
	1.65	31	<10	25	<10
	1.57	25	<10	45	<10
	1.44	26	<10	20	<10
12/15	1.44	125	<10	40	<10
	1.21	41	<10	30	<10
	1.56	49	<10	65	<10
	1.76	77	<10	125	<10
	1.55	45	<10	45	<10
	1.34	103	<10	30	<10
	1.13	36	<10	20	<10

[a] Refer to table 4 for explanation of analytical errors. The concentration of strontium-89 in all samples was less than 5 pCi/liter.

[b] Data have been corrected for decay to the date of sample collection.

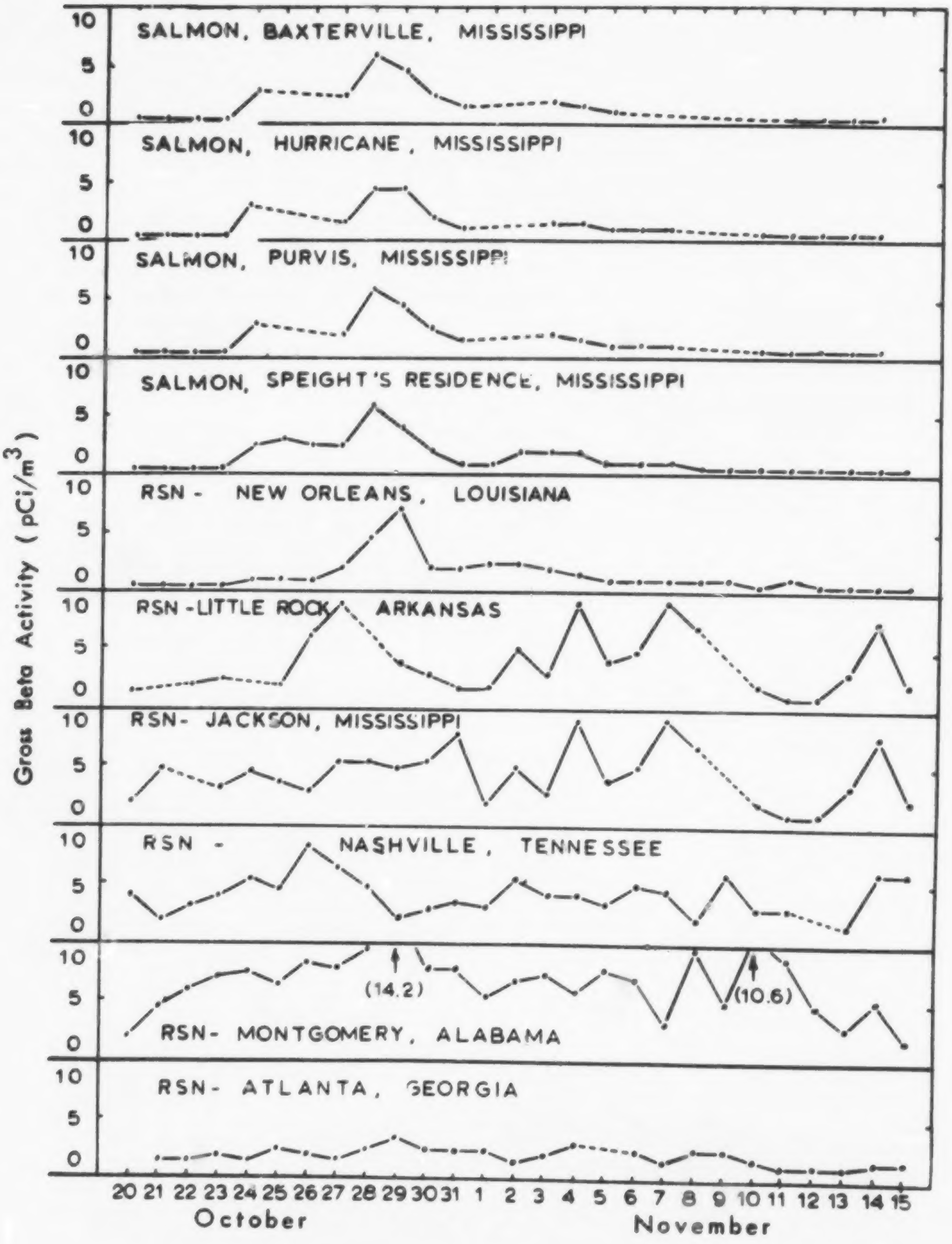

Figure 3. Comparison of Salmon event and RSN air sampling data

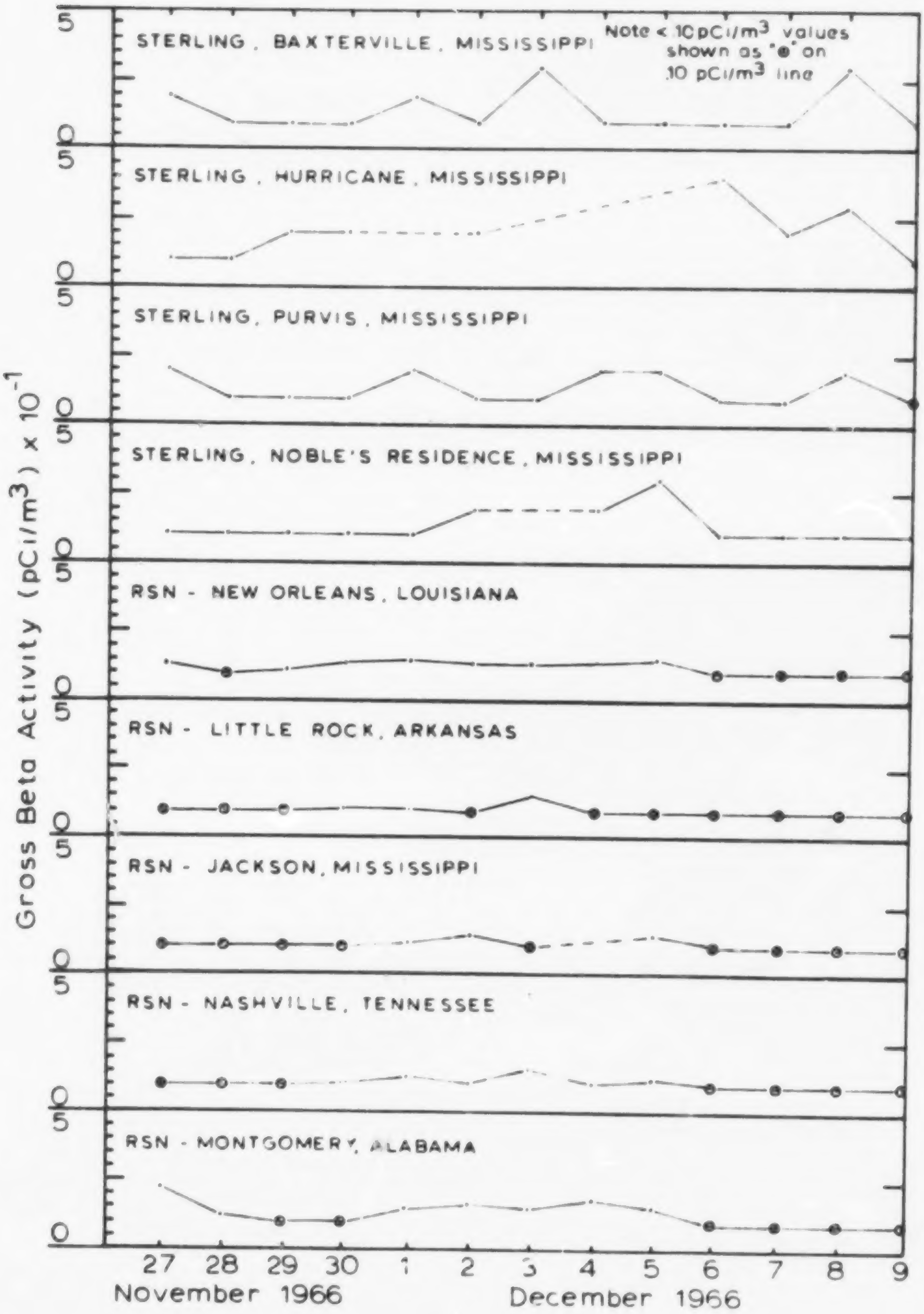

Figure 4. Comparison of Sterling event and RSN air sampling data

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Table 4. Analytical errors associated with determinations of radionuclide concentrations in milk[a]

Radionuclide	Concentration (pCi/liter)	Error [b] (pCi/liter)	Concentration (pCi/liter)	Error [b] (percent of concentration)
Iodine-131	<100	10	≥100	10
Barium-140	<100	10	≥100	10
Cesium-137	<100	10	≥100	10
Strontium-89	< 50	5	≥ 50	10
Strontium-90	< 20	2	≥ 20	10

[a] This table is approximate and should not be used for precise determinations of errors.

[b] Two standard deviations.

event in comparison to the Salmon event was that between 1964 and 1966 a number of dairymen went out of business; therefore, it was impossible to sample the same dairy farms for the two events. This situation was true for the noncommercial sampling program, *i.e.*, less people were milking cows within a 5-mile radius of the site in 1966 than in 1964; therefore, the number of offsite milk sampling stations for Sterling was not the same as for Salmon.

As previously indicated, a rise in gross beta radioactivity levels was detected in late October and early November of 1964, during the same time period as the Salmon shot; however, air radioactivity data from PHS, RSN stations in this general area also indicated this rise in activity, with the exception of Atlanta, Ga. This indicates that the radioactivity detected in the area of the Salmon shot was most probably a part of generalized atmospheric fallout attributed to the foreign atmospheric nuclear test conducted in the atmosphere on October 16, 1964. Figure 3 presents a comparison of air data for a selected number of Salmon stations with RSN data (*1*), and figure 4 shows a similar comparison of Sterling air data.

No radioactivity above background was detected in the local offsite environment during Salmon or Sterling that could be attributed to either of the shots. A continuous program of water sampling has been conducted around the test site area since the spring of 1963. The sampling program includes private, stream, and public supplies. No radioactivity above background has been detected.

During both events, ground monitoring teams were employed in the field. An average of 27 ground monitoring teams participated during both events. Each team was equipped with beta-gamma-type field survey instruments, and mobile air sampling capability. They were directed in the field through a central radio control system.

An aerial monitoring team as well as an aerial cloud sampling team participated in both events. The teams were employed in the field until project officials determined that it was safe to terminate radiation monitoring activities. All aerial monitoring activities for the two events indicated no radioactivity above background.

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Suggested Biological Monitoring for Radon Daughter Exposure

Victor E. Archer[1]

Methods for accurately determining the radiation exposure of underground uranium miners have become of increasing importance since official action has been taken to keep their exposures below specified limits (*1*). Discussed in this note are the present monitoring techniques for radon daughter exposure and suggested biological indicators that may prove useful for determining radon daughter exposure.

Air sampling

Periodic air sampling for radon daughters is the only method currently used to estimate exposure. This method has several inherent defects as a means of determining the exposure of individuals. First, marked fluctuations of radon daughter products occur in space and time within any mine. It is not practical to take air samples at the particular point where each man is breathing, so that air measurements rarely reflect with accuracy the radionuclide concentration in the air actually breathed. Also, fluctuations in air concentrations occur between the times that sampling is done. The longer the frequency between samplings, the greater is the opportunity for undetected fluctuations. Second, physical factors such as dust concentration, particle size distribution, humidity and temperature, which affect the fraction of airborne radionuclides that reaches the critical tissue, are uncontrollable variables. Third, physiological factors, such as rate and depth of breathing, degree of constriction of bronchi and bronchioles, thickness of mucus blanket overlying bronchial epithelium and pulmonary clearance rates are also uncontrollable factors in determining actual exposure to the critical tissue.

Biological indicators

Because of the many uncontrollable factors involved in relating air concentrations to actual exposure of critical tissue, a biological monitoring system is highly desirable. Since the short half-life daughters of radon decay to lead-210 and polonium-210, which have relatively long half-lives, it seems reasonable to suppose that one or both of them could be measured in urine, feces, hair, or body tissues to serve as biological indicators of radiation exposure of men working underground in uranium mines.

A number of publications have reported urine and tissue analyses for these two radionuclides in uranium miners and in non-miners (*2–18*). One of these has established a quantitative relationship between cumulative exposure and bone concentrations of lead-210 (*6*). Although similar relationships have not been quantitatively established between exposure and other items of interest, the data referred to above (*2–18*) can be used to make estimates that should be useful in initiating biological monitoring programs, and will serve as guides until more precise data are developed. These estimates for urine are given in table 1.

It has been noted previously that the polonium-210 and lead-210 contents of urine reflect two different aspects of their metabolism (*2*). The first aspect, represented by the first four estimates in table 1, reflects that portion of polonium-210 and lead-210 that is rather promptly excreted following its intake. The second aspect, represented by the last four estimates in table 1, reflects a slow excretion rate from body deposits of these radionuclides. A comparison of the urine concentrations estimated to result from current exposure with those from cumulative exposure (largely bone deposits) indicates that those radionuclides in urine representing cumulative exposure will not

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Table 1. Predicted concentrations of ^{210}Po and ^{210}Pb in urine which correspond to selected radiation exposure values of interest for control purposes

Selected exposures	Predicted radioactivity (pCi/liter)	
	^{210}Po	^{210}Pb
Estimated concentration in urine during exposure at 0.3 working level	0.2	0.3
Estimated concentration in urine during exposure at 1.0 working level	0.3	0.8
Estimated concentration in urine following cumulative exposure of 100 working level months after subject has stopped mining for 1 or 2 months	0.06	0.09
Estimated concentration in urine following cumulative exposure to 400 working level months after subject has stopped mining for 1 or 2 months	0.2	0.3

seriously interfere with measurement for current exposure until cumulative exposure approximates 400 working level months.[2] For a man whose exposure is considerably greater than 400 working level months, urinalysis would not likely be a practical means of evaluating subsequent exposure rates.

Additional indicators

Four other items are of special interest for monitoring purposes: bone, which is of value in estimating cumulative radiation exposure at death; blood, feces, and hair, which may be of value in estimating intensity of mine exposure in the recent past. Due to absence of data, no estimate can be made at this time for the radionuclide concentrations in blood or feces which might correspond to a current exposure at one working level. It is likely, however, that the concentrations in blood would not be much higher than that found in urine at the same point in time.

Since hair grows slowly, and reflects blood concentrations at the time of formation, hair radionuclide content may be expected to reflect blood concentrations averaged over a period of 6 to 15 months (depending on length of hair available for analysis) (*21*). Bone concentrations cannot be expected to reflect recent or current exposures to an appreciable extent. Hair and bone concentrations based on reported measurements which are estimated to correspond to designated radiation exposures are given in table 2 (*2–18*).

Table 2. Predicted concentrations of ^{210}Po and ^{210}Pb in hair and bone which correspond to selected radiation exposure values of interest for control purposes

Selected exposures	Predicted radioactivity (pCi/g)	
	^{210}Po	^{210}Pb
Estimated concentration in hair following 6 to 15 months exposure at 0.3 working level	1.0	0.4
Estimated concentration in hair following 6 to 15 months exposure at 1.0 working level	3.0	1.0
Estimated concentration in bone within a few years after end of mining, which corresponds to 100 working level months	0.08	0.09
Estimated concentration in bone within a few years after end of mining, which corresponds to 400 working level months	0.2	0.3

The numbers given in tables 1 and 2 are likely to be correct within a factor of 2. Additional research is needed to refine them further. Crude as the numbers are, they may prove helpful in developing biological monitoring procedures to detect and/or prevent radiation over-exposure among uranium miners. The numbers in tables 1 and 2 corresponding to an exposure rate at 0.3 working level and to cumulative exposure of 100 working level months are not greatly different from normal values in non-miners. Biological monitoring at these levels will therefore present a problem unless very sensitive detection methods similar to ones recently described are used (*4,16,19*).

In addition to the radionuclide concentrations in urine and tissues mentioned above, it is quite possible that measurement of radionuclide concentrations in saliva or in a small amount of water used to rinse out the mouth at the end of a day's work would be useful for biological monitoring. As with blood and feces, insufficient work has been done with this material to warrant estimates of concentrations that might correspond to an 8-hour exposure at 0.3 or 1.0 working level. Measurement of saliva or mouth-rinses would probably require less sensitive equipment than the other measurements discussed above, as many of the short half-life daughters of radon would be present. Separation of specific radionuclides might be unnecessary for monitoring purposes.

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[2] One working level is equivalent to 100 pCi of radon-222 at equilibrium with its daughters per liter of air. A working level month represents the cumulative radiation exposure for 1 month.

Even if the radionuclide concentration in hair can be shown to accurately reflect mine exposures, its use has four inherent drawbacks: (1) Expensive and time consuming sample preparation (hair must be digested before its content of alpha- or beta-emitters can be determined); (2) External contamination from radon and dust present in the air of mines (this would probably be difficult to wash off (*20*)); (3) Time element (concentrations in hair can not reflect over-exposures as they occur, but would reflect exposures which had occurred weeks before sampling (*21*)); (4) Differences in personal hygiene (the frequency of washing hair and face, and the different detergents employed, might result in different degrees of leaching, as well as different degrees of surface contamination of hair samples).

Summary

Present methods of sample preparation and measurement appear to be too time consuming and delicate to be practical for routine monitoring purposes (*2*). To be practical, quicker methods which can be performed promptly by relatively untrained personnel, must be developed. Two methods appear to hold promise: determination of gamma rays from saliva or mouth-rinse by scintillation well-type counters, and determination of alpha or beta radiation from saliva, mouth-rinse, or urine after simple sample preparation by liquid scintillation counting systems. Development of some such simple system is urgently needed.

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Data

SECTION I. MILK AND FOOD

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Both Federal and State agencies are involved in efforts to monitor continously the dietary intake of radionuclides. The most direct measure of radionuclide intake would be obtained through radioanalysis of the total diet. Difficulties in obtaining specific dietary data impede this approach. An alternate method entails the use of indicator foods to arrive at an estimate of the total dietary radionuclide intake.

Milk is one such indicator food. It is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides which appear in the diet. It also is one of the major sources of dietary intake for the short-lived radionuclides. For these reasons, milk is the single food item most often used in estimating the intake of selected radionuclides by the general population and/or specific population groups. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission on Radiological Protection (*5,6*).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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National and International Milk Surveillance

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide levels in milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in milk, HASL	July-December 1966	September 1967

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1. Pasteurized Milk Network
October 1967

National Center for Radiological Health and *National Center for Urban and Industrial Health, PHS*

The Public Health Service's Pasteurized Milk Network (PMN) was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 stations (figure 1) provides data on milk in every State, the Canal Zone, Puerto Rico, and Washington, D.C. The most recent description of the sampling and analytical procedures employed by the PMN

Table 1. Analytical errors associated with determinations of radionuclide concentrations in milk

Nuclide	Concentration (pCi/liter)	Error [a] (pCi/liter)	Concentration (pCi/liter)	Error [a] (percent of concentration)
Strontium-89	< 50	5	≥ 50	10
Strontium-90	< 20	2	≥ 20	10
Iodine-131	<100	10	≥100	10
Cesium-137	<100	10	≥100	10
Barium-140	<100	10	≥100	10

[a] Two standard deviations.

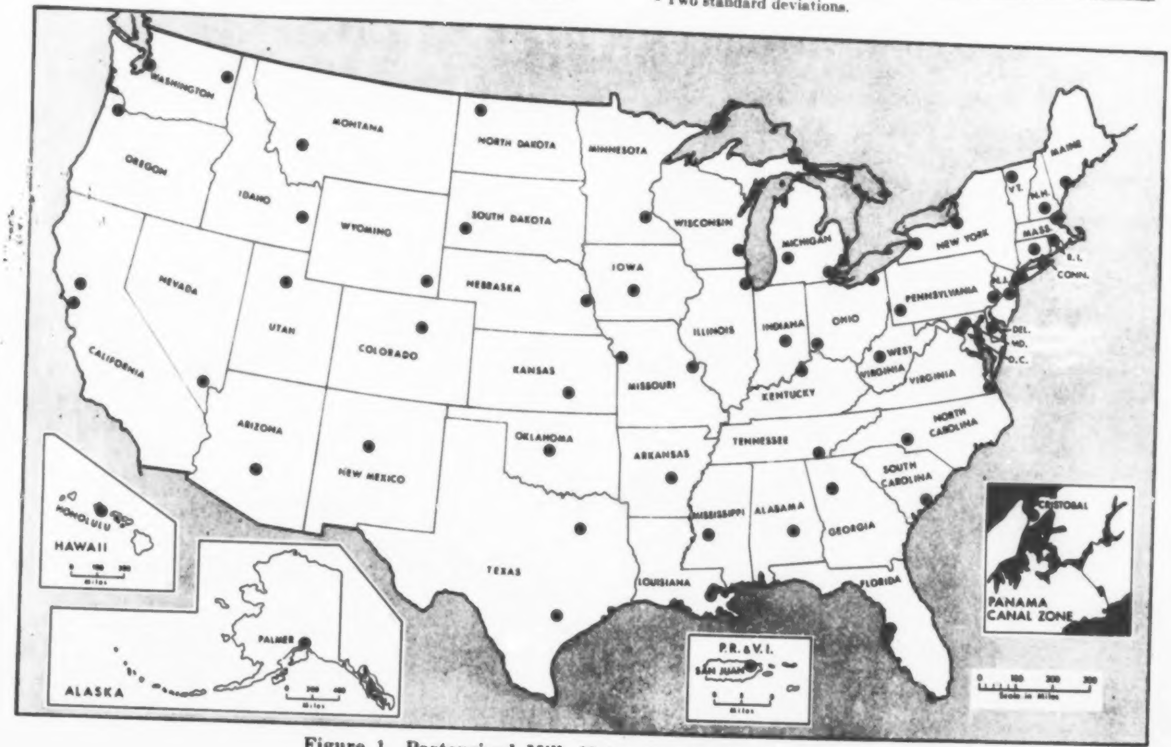

Figure 1. Pasteurized Milk Network sampling stations

Table 2. Average concentrations of radionuclides in pasteurized milk for October 1967 and the 12-month period, November 1966 through October 1967

Sample location		Radionuclide concentration (pCi/liter)									
		Strontium-89		Strontium-90		Cesium-137		Iodine-131		Barium-140	
		Nov. 1966 ᵃ Oct. 1967	Oct. 1967ᵃ	Nov. 1966- Oct. 1967	Oct. 1967	Nov. 1966- Oct. 1967	Oct. 1967	Nov. 1966- Oct. 1967	Oct. 1967	Nov. 1966- Oct. 1967	Oct. 1967
Ala:	Montgomery	0	0	10.4	8.4	16	17	2	0	0	0
Alaska:	Palmer	0	0	8.5	6.6	22	16	0	0	0	0
Ariz:	Phoenix	0	0	1.6	1.4	2	0	0	0	0	0
Ark:	Little Rock	1	0	24.1	19.9	20	14	1	0	1	0
Calif:	Sacramento	2	0	3.3	2.7	4	0	2	0	0	0
	San Francisco	3	0	3.4	1.5	2	0	1	0	1	0
C. Z:	Cristobal	0	0	4.7	2.3	22	10	0	0	0	0
Colo:	Denver	0	0	6.3	5.1	5	3	1	0	0	0
Conn:	Hartford	0	......	9.4	8.0	20	14	1	0	0	0
Del:	Wilmington	0	......	11.5	9.8	16	7	1	0	0	0
D. C:	Washington	0	0	10.4	9.8	11	6	0	0	0	0
Fla:	Tampa	1	0	8.7	7.9	77	80	1	0	0	0
Ga:	Atlanta	0	0	15.7	13.5	25	21	3	0	0	0
Hawaii:	Honolulu	0	0	4.0	2.2	11	5	1	0	2	0
Idaho:	Idaho Falls	1	1	6.9	6.2	9	12	1	0	0	0
Ill:	Chicago	0	0	8.6	7.3	16	6	1	0	0	0
Ind:	Indianapolis	0	......	9.2	6.5	12	5	1	0	0	0
Iowa:	Des Moines	1	0	8.3	7.2	8	0	0	0	1	0
Kans:	Wichita	1	0	9.3	8.8	5	4	0	0	0	3
Ky:	Louisville	2	0	13.7	11.7	9	1	0	0	1	0
La:	New Orleans	1	0	25.4	21.8	30	24	1	0	1	0
Maine:	Portland	0	......	12.4	9.9	39	29	0	0	0	0
Md:	Baltimore	0	0	11.2	10.9	13	0	1	0	0	0
Mass:	Boston	0	0	12.5	10.3	33	24	0	0	0	0
Mich:	Detroit	0	......	9.2	8.4	16	5	1	0	0	0
	Grand Rapids	0	......	10.5	6.4	20	8	0	0	0	0
Minn:	Minneapolis	1	0	14.5	10.0	14	11	0	0	0	0
Miss:	Jackson	2	0	19.2	15.7	17	18	2	0	1	0
Mo:	Kansas City	1	0	10.0	9.1	4	4	1	0	1	5
	St. Louis	2	0	10.4	9.3	8	7	0	0	2	0
Mont:	Helena	1	0	7.4	5.4	11	11	0	0	0	0
Nebr:	Omaha	0	0	9.2	3.4	6	2	1	0	0	0
Nev:	Las Vegas	0	0	1.9	1.4	2	0	0	0	0	0
N. H:	Manchester	0	......	14.8	9.3	46	31	0	0	0	0
N. J:	Trenton	0	......	10.0	9.6	17	11	0	0	0	0
N. Mex:	Albuquerque	0	0	3.5	1.5	2	2	0	0	0	0
N. Y:	Buffalo	0	......	8.6	7.8	17	4	0	0	1	0
	New York City	0	......	11.5	9.9	19	5	0	0	0	0
	Syracuse	0	......	9.3	10.2	20	14	1	0	0	0
N. C:	Charlotte	0	0	18.1	16.5	17	10	0	0	1	0
N. Dak:	Minot	3	3	15.9	10.9	15	6	0	0	1	0
Ohio:	Cincinnati	0	......	10.0	6.9	11	5	0	0	0	0
	Cleveland	0	......	10.3	8.8	16	0	1	0	0	0
Okla:	Oklahoma City	0	0	10.4	9.4	6	2	1	0	0	0
Ore:	Portland	2	0	8.5	7.0	15	12	2	0	0	0
Pa:	Philadelphia	0	......	10.2	9.3	13	0	1	0	0	0
	Pittsburgh	0	......	13.4	9.8	21	14	2	0	0	0
P. R:	San Juan	2	0	5.1	5.1	15	20	0	0	0	0
R. I:	Providence	0	......	11.5	10.5	27	17	0	0	0	0
S. C:	Charleston	0	0	16.9	14.4	32	33	4	0	0	0
S. Dak:	Rapid City	2	0	12.3	10.3	14	4	1	0	1	0
Tenn:	Chattanooga	0	0	16.8	16.4	17	11	1	0	1	0
	Memphis	0	0	13.8	12.5	5	3	1	0	0	0
Tex:	Austin	0	0	3.7	4.7	4	3	5	0	0	0
	Dallas	0	0	9.4	7.4	8	0	2	0	0	0
Utah:	Salt Lake City	1	9	7.3	5.7	10	6	1	0	1	4
Vt:	Burlington	0	......	10.8	8.2	21	10	1	0	0	0
Va:	Norfolk	1	0	12.9	12.1	11	6	1	0	1	1
Wash:	Seattle	2	0	11.3	8.7	30	25	0	0	0	2
	Spokane	0	0	10.5	6.7	21	18	0	0	0	0
W. Va:	Charleston	0	0	12.8	9.0	8	2	0	0	0	0
Wisc:	Milwaukee	0	......	7.7	6.3	16	8	0	0	0	0
Wyo:	Laramie	0	0	5.8	4.9	6	9	0		0	0
Network average		1	0	10.4	8.5	16	10	1	0	0	0

ᵃ Blank indicates no strontium-89 determinations were made on samples from station during month.

appeared in the January 1968 issue of *Radiological Health Data and Reports* (*1*).

Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly the minimum detectable concentrations in pCi/liter are: strontium–89, 5; strontium–90, 2; cesium–137, 10; barium–140, 10; iodine–131, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

In past issues, the presentation of data has included a table of average concentrations for the month and most recent quarter. Beginning with this issue, the quarterly average has been replaced by an annual average for the 12-month period ending with the month being reported. This will facilitate evaluations of population exposure with respect to the guidance provided by the Federal Radiation Council, which suggests average total daily intakes averaged over periods of a year, as an appropriate criterion (*2*). Thus, table 2 contains averages for October 1967 and 12-month averages for the period November 1966 through October 1967.

The average radionuclide concentrations are based on results obtained from samples collected weekly. In previous reports these averages were rounded as follows prior to tabulation: strontium–90, nearest whole number; strontium–89 and cesium–137, nearest 5; iodine–131 and barium–140, nearest 10. Since the analytical error associated with the determination of these radionuclides in milk is presented in conjunction with the data, the rounding procedure has been discontinued and the averages are given to the same accuracy as the weekly concentrations reported by the laboratories, *i.e.*, the nearest whole number for all the

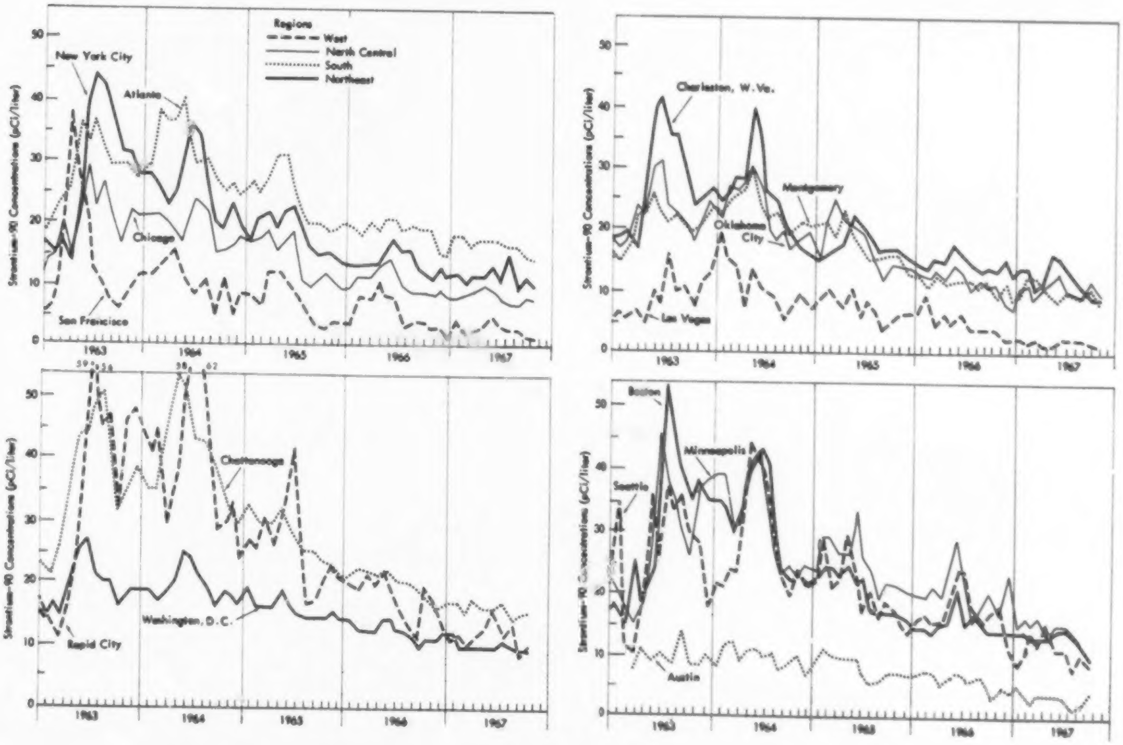

Figure 2. Strontium–90 concentrations in pasteurized milk, 1961–October 1967

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radionuclides except strontium–90, which is reported to the nearest tenth.

Another change from past reports is in the interpretation for averaging purposes of weekly values below minimum detectable concentrations. For the sake of consistency, zero is now used for all the radionuclides, instead of only iodine–131 and barium–140, whenever concentrations are less than or equal to the appropriate minimum detectable levels.

For comparative purposes, distributions of strontium–90 and cesium–137 are presented in tables 3 and 4 for October 1966, and May through October 1967. The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

Table 3. Frequency distribution, strontium–90 concentrations at PMN stations, October 1966 and May–October 1967

Strontium-90 (pCi/liter)	Number of stations						
	1966	1967					
	Oct.	May	June	July	Aug.	Sept.	Oct.
Under 10	18	25	27	25	35	37	46
10-19	39	35	34	35	26	24	16
20-29	6	3	2	3	2	2	1

Table 4. Frequency distribution, cesium–137 concentrations at PMN stations, October 1966 and May–October 1967

Cesium-137 (pCi/liter)	Number of stations						
	1966	1967					
	Oct.	May	June	July	Aug.	Sept.	Oct.
Under 50	62	61	61	61	61	62	62
50-99	0	2	2	2	2	1	1
100-149	1	0	0	0	0	0	0

2. Canadian Milk Network
October 1967[1]

Radiation Protection Division
Department of National Health and Welfare

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

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[1] Prepared from November 1967 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

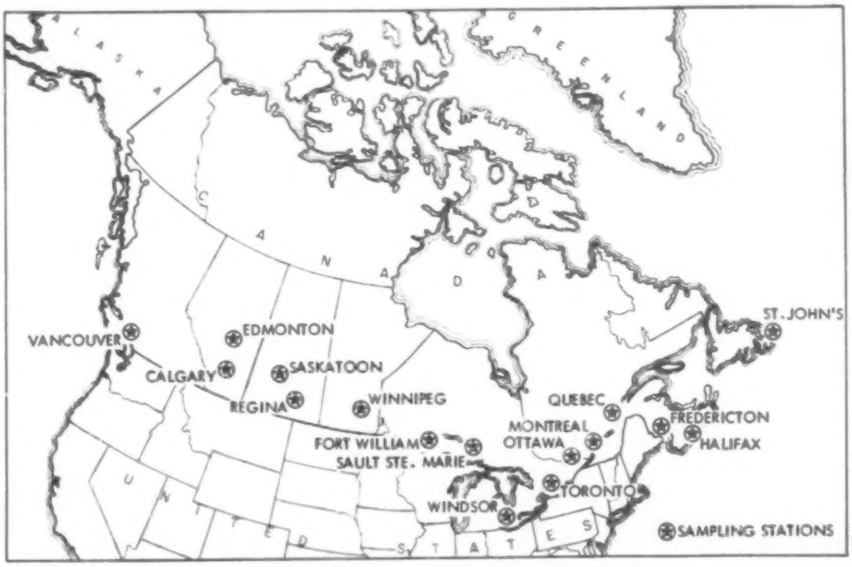

Figure 3. Canadian milk sampling stations

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the December 1966 issue of *Radiological Health Data and Reports* (*3*).

The October 1967 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 5. Iodine–131 and strontium–89 concentrations were below minimum detectable levels.

Table 5. Stable elements and radionuclides in Canadian whole milk, October 1967

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.19	1.5	9.4	14
Edmonton	1.12	1.5	8.1	24
Ft. William	1.08	1.6	14.7	30
Fredericton	1.08	1.5	16.1	23
Halifax	1.14	1.5	14.6	26
Montreal	1.08	1.5	9.8	16
Ottawa	1.12	1.6	8.6	14
Quebec	1.12	1.5	13.6	22
Regina	1.12	1.5	8.7	14
St. John's. Nfld	1.12	1.5	20.6	34
Saskatoon	1.11	1.5	9.4	11
Sault Ste. Marie	1.10	1.5	16.5	31
Toronto	1.13	1.5	5.6	13
Vancouver	1.21	1.5	15.2	51
Windsor	1.11	1.5	4.4	11
Winnipeg	1.18	1.7	8.6	18
Average	1.13	1.5	11.5	22

3. Pan American Milk Sampling Program October 1967

Pan American Health and Organization and *U.S. Public Health Service*

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American republics in developing national radiological health programs.

Under a joint agreement between agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (*4*).

Table 6 presents stable potassium, strontium–90 and cesium–137 monthly concentrations for October 1967.

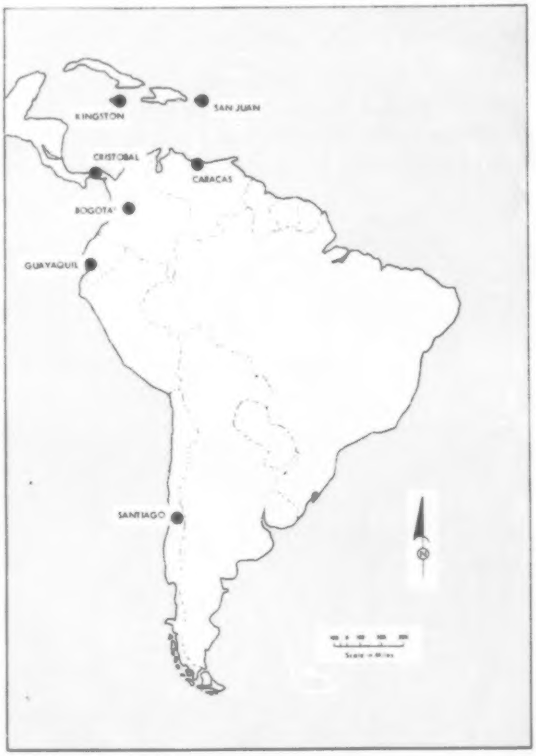

Figure 4. Pan American Milk Sampling Program stations

Table 6. Stable element and radionuclide concentrations in PAHO milk, October 1967[a]

Sampling station	Number of samples	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Colombia: Bogota	1	1.49	1	< 5
Chile: Santiago	1	1.53	<1	< 5
Ecuador: Guayaquil	1	1.61	<1	20
Jamaica: Kingston	1	1.46	5	85
Venezuela: Caracas	1	1.57	3	10
Canal Zone: Cristobal [b]	5	1.48	3	15
Puerto Rico: San Juan [b]	5	1.57	5	20

[a] Strontium-89 was less than 5 pCi/liter and iodine-131 and barium-140 were less than 10 pCi/liter for all samples.

[b] For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone, and San Juan, Puerto Rico, from the Pasteurized Milk Network, are presented.

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(1) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, September 1967. Radiol Health Data Rep 8:20–23 (January 1968).

(2) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1960).

(3) DEPARTMENT OF NATIONAL HEALTH AND WELFARE, RADIATION PROTECTION DIVISION. Canadian milk network, August 1966. Radiol Health Data Rep 7:702–703 (December 1966).

(4) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1966. Radiol Health Data Rep 7:704–705 (December 1966).

State Milk Surveillance Activities

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have reached a point of having comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes at this time. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

Figure 1 shows the States which report milk surveillance activities in *Radiological Health Data and Reports*. States having programs ap-

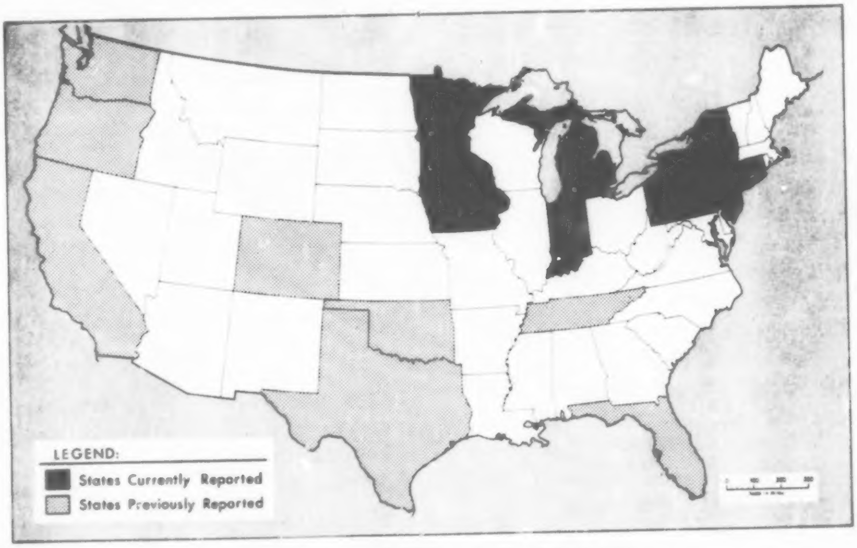

Figure 1. Reported State milk programs

pearing in the current issue are highlighted in the figure. A summary of State programs previously covered, the reporting period, and issue of appearance are as follows:

State milk network	Period reported	Last presented
California	April–June 1967	December 1967
Colorado	July–September 1967	January 1968
Florida	July–September 1967	January 1968
Oklahoma	July–September 1967	January 1968
Oregon	April–June 1967	December 1967
Tennessee	July–September 1967	January 1968
Texas	July–September 1967	January 1968
Washington	April–June 1967	December 1967

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1. Connecticut Milk Network
July–September 1967

Connecticut State Department of Health

The Connecticut State Department of Health has been monitoring pasteurized milk for strontium–89 and strontium–90 since April 1960. In May 1962, the program was expanded to include the determination of gamma-emitting radionuclides in milk.

The sampling program is flexible in nature, providing for sampling in five areas of the State (figure 2). At the present time, weekly samples representative of milk sold in the central area of the State are collected and analyzed for strontium–89, strontium–90, and gamma-ray emitters. Concentrations of iodine–131 are determined as an indication of the presence of radioactivity of recent origin.

Strontium–89 and strontium–90 are determined by chemical separation. Iodine–131 and other gamma-ray emitters are determined by gamma-ray scintillation spectroscopy.

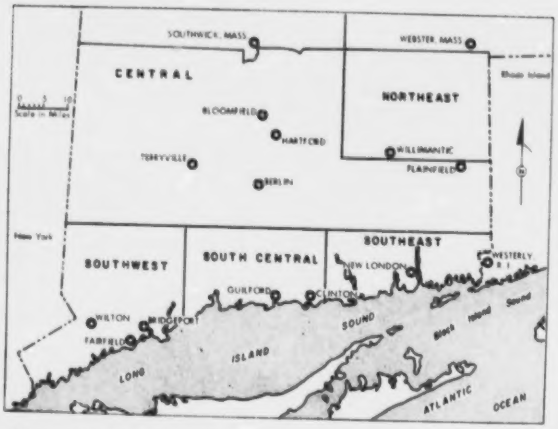

Figure 2. Connecticut pasteurized milk sampling stations

The monthly average concentrations of strontium–89, strontium–90, iodine–131, and cesium–137, in central Connecticut pasteurized milk are presented in table 1. These results are presented graphically in figure 2.

Table 1. Radionuclide concentrations in central Connecticut pasteurized milk, July–September 1967

Month	Radionuclide concentration (pCi/liter)			
	Strontium-89	Strontium-90	Iodine-131	Cesium-137
July	ND	10	ND	20
August	ND	10	ND	20
September	ND	10	ND	10

ND, below detectable levels.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
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April–June 1967	November 1967

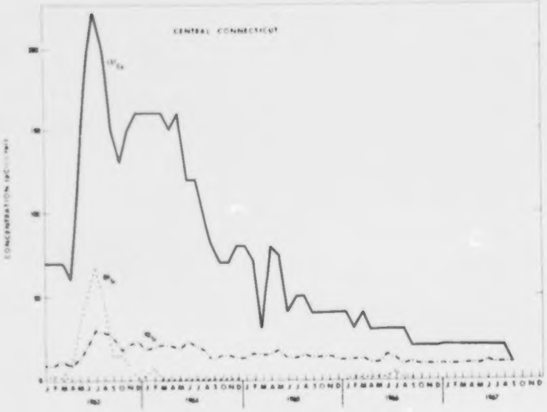

Figure 3. Radionuclide concentrations in central Connecticut pasteurized milk, 1963—September 1967

2. Indiana Milk Network July–September 1967

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radionuclide analysis in September 1961. The State was geographically divided into five major milksheds; northeast, northwest, central, southeast, and southwest (figure 4). One large diary within each milkshed was assumed to be representative for sampling purposes.

The milk samples are analyzed monthly for strontium-89 and strontium-90. Cesium-137, iodine-131, and barium-140 are analyzed weekly for at least two of the milksheds. When iodine-131 concentrations exceed 100 pCi/liter, the sampling frequency is increased. From August 1963 to April 1966, because of the continued low concentrations of short-lived radionuclides, the sampling frequency was once a month for the northeast, southeast, and southwest milksheds.

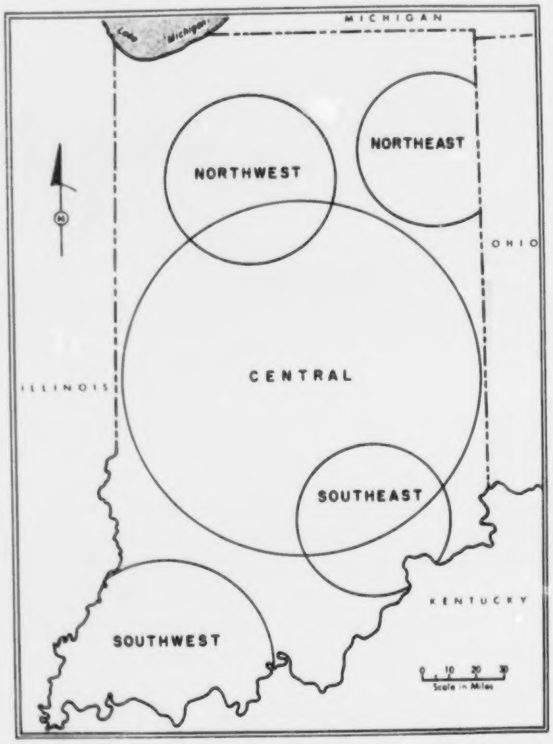

Figure 4. Indiana pasteurized milk sampling stations

Table 2. Stable element and radionuclides in Indiana pasteurized milk, July–September 1967

Sampling location	Calcium (g/liter)			Potassium-40 (pCi/liter)			Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
	July	August	Sept	July	August	Sept	July	August	Sept	July	August	Sept
Northeast	1.08	1.11	1.13	1,330	1,230	1,260	12	9	18	15	15	10
Southeast	1.15	1.13	1.17	1,430	1,260	1,360	13	11	11	20	15	20
Central	1.14	1.13	1.11	1,320	1,310	1,290	9	7	8	15	5	10
Southwest	1.15	1.16	1.11	1,380	1,250	1,240	10	12	12	10	10	15
Northwest	1.07	1.12	1.14	1,360	1,300	1,330	9	10	9	15	10	5
Average	1.12	1.13	1.13	1,360	1,270	1,300	11	10	12	15	11	12

Strontium-89 and strontium-90 concentrations in milk samples are determined by ion exchange separation (*1,2*) while cesium-137, iodine-131, and barium-140 are determined by gamma-ray scintillation spectrometry (*3*).

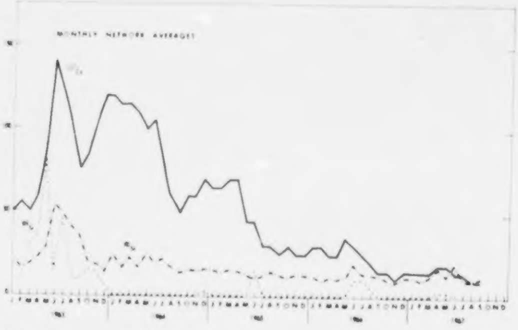

Figure 5. Radionuclide concentrations in Indiana pasteurized milk, 1961–September 1967

The monthly stable element and radionuclide concentrations in Indiana pasteurized milk are presented by sampling locations in table 2 for July through September 1967.

The monthly network average concentrations of strontium-89, strontium-90, and cesium-137 are presented graphically in figure 5. Barium-140 and iodine-131 concentrations remained below detectable levels of 10 pCi/liter and strontium-89 concentrations remained below detectable levels of 0.6 pCi/liter during this period.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
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3. Iowa Milk Network
July–September 1967

State Hygienic Laboratory and the
Iowa State Department of Health

In Iowa, radiological health activities are conducted jointly by the State Department of Health and the State Hygienic Laboratory, with the State Hygienic Laboratory performing the surveillance and analytical functions.

In August 1962 the State Hygienic Laboratory of Iowa began sampling milk for iodine-131. In May 1964 this routine surveillance was expanded to include cesium-137 and strontium-90.

One gallon samples are collected from 4 stations, selected to give a broad coverage of milk production areas in the State (figure 6). Producers furnishing milk to the Spencer bottling area are quite restricted to that northwest part of the State and the majority of milk bottled

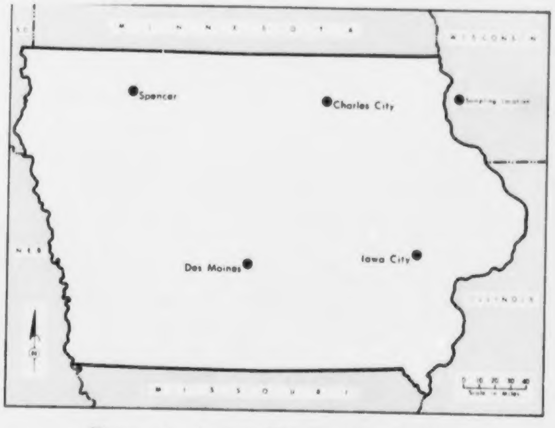

Figure 6. Iowa milk sampling stations

in Iowa City comes from six counties in east central Iowa. The Des Moines milkshed comprises approximately 60 countries covering about two thirds of the State radiating out of Des Moines in all directions. The Charles City bottling area covers primarily north central Iowa. At present the Iowa City and Des Moines stations are sampled weekly and the Spencer and Charles City stations are sampled monthly. This sampling frequency is increased when nuclide concentrations warrant closer surveillance. The samples are forwarded to the State Hygienic Laboratory at the University of Iowa, Iowa City, for analysis.

Analytical procedures

Iodine–131 and cesium–137 together with barium-lanthanum–140 and potassium–40 are determined by gamma-scintillation spectrometry using a 4- by 4-inch NaI (T1) crystal and 512 channel pulse-height analyzer. All samples are 3.5 liters and are counted for 80 minutes in Marinelli beakers with the results being calculated using a 4 by 4 matrix. Strontium–90 is determined by an ion-exchange system described by Porter, *et al* (*4*). One liter of milk is passed through an ion exchange column; yttrium–90 is eluted from the resin and counted as yttrium oxalate in an automatic low-background proportional counter. Minimum detectable limits are 10 pCi/liter for iodine–131 and cesium–137 and 2 pCi/liter for strontium–90.

Results

Table 3 gives the monthly averages at each of the four locations for July-September 1967 and figure 7 shows graphically the overall network average monthly results for the same period. During this period it can be seen that the concentration levels of cesium–137 and strontium–90 showed a decreasing trend. Iodine–131 was only present to any significant amount during the month of June 1965.

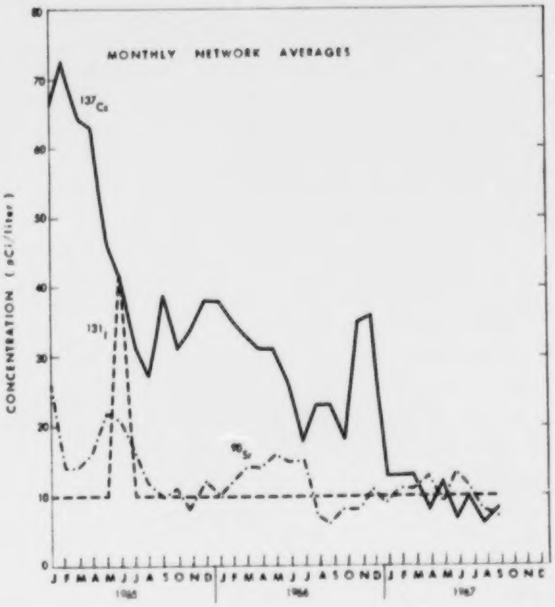

Figure 7. Radionuclide concentrations in Iowa milk January 1965–September 1967

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1967	August 1967
April–June 1967	November 1967

Table 3. Radionuclide concentrations in Iowa milk, July–September 1967

Sampling location	Radionuclide concentration (pCi/liter)								
	Strontium-90			Cesium-137			Iodine-131		
	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept
Iowa City	9	9	8	<10	<10	<10	<10	<10	<10
Des Moines	9	10	5	<10	<10	<10	<10	<10	<10
Spencer	14	6	8	11	<10	<10	<10	<10	<10
Charles City	NA	NA	NA	NA	NA	NA	NA	NA	NA
Average	11	8	7	<10	<10	<10	<10	<10	<10

NA, no analysis.

4. Michigan Milk Network
July–September 1967

Division of Occupational Health
Michigan Department of Health

The Michigan Department of Health began sampling pasteurized milk for radionuclide analyses in November 1962. Under this program, weekly pasteurized milk samples are collected in the seven major milk producing areas in the State: Charlevoix, Detroit, Grand Rapids, Lansing, Marquette, Monroe, and Saginaw (figure 8). Milkshed samples are composites from dairies in proportion to sales volumes.

Strontium-90 concentrations are determined by an ion exchange method (*5*). Potassium-40, iodine-131, cesium-137, and barium-lanthanum-140 concentrations are determined by gamma-ray scintillation spectrometry (*5*).

Table 5 presents the monthly average radionuclide concentrations in Michigan pasteurized milk. Strontium-90 and cesium-137 concentrations are presented graphically in figure 9 to show general trends.

Table 5. Radionuclide concentration in Michigan pasteurized milk, July–September 1967

Sampling location	Month	Radionuclide concentrations (pCi/liter)			
		Potassium-40	Strontium-90	Iodine-131	Cesium-137
Charlevoix	July August September	1,350 1,360 1,360	6 4 4	<14 <14 <14	13 12 9
Detroit	July August September	1,320 1,340 1,320	5 4 4	<14 <14 <14	9 7 7
Grand Rapids	July August September	1,280 1,330 1,320	5 5 3	<14 <14 <14	15 10 10
Lansing	July August September	1,330 1,350 1,290	6 4 3	<14 <14 <14	10 10 6
Marquette	July August September	1,320 1,330 1,310	10 9 8	<14 <14 <14	37 33 24
Monroe	July August September	1,360 1,300 1,330	4 3 3	<14 <14 <14	7 5 7
Saginaw	July August September	1,330 1,290 1,340	5 3 2	<14 <14 <14	11 8 7
Average	July August September	1,330 1,330 1,320	6 5 4	<14 <14 <14	15 12 10

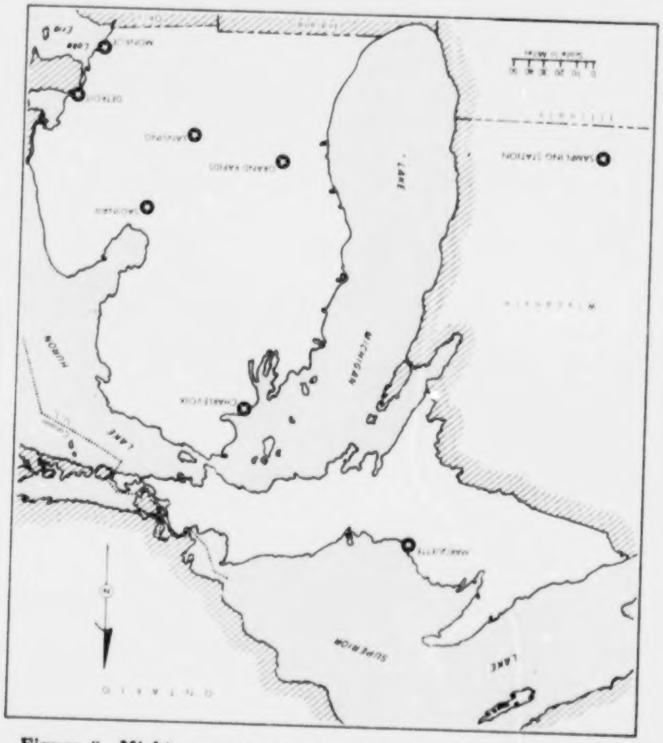

Figure 8. Michigan pasteurized milk network sampling stations

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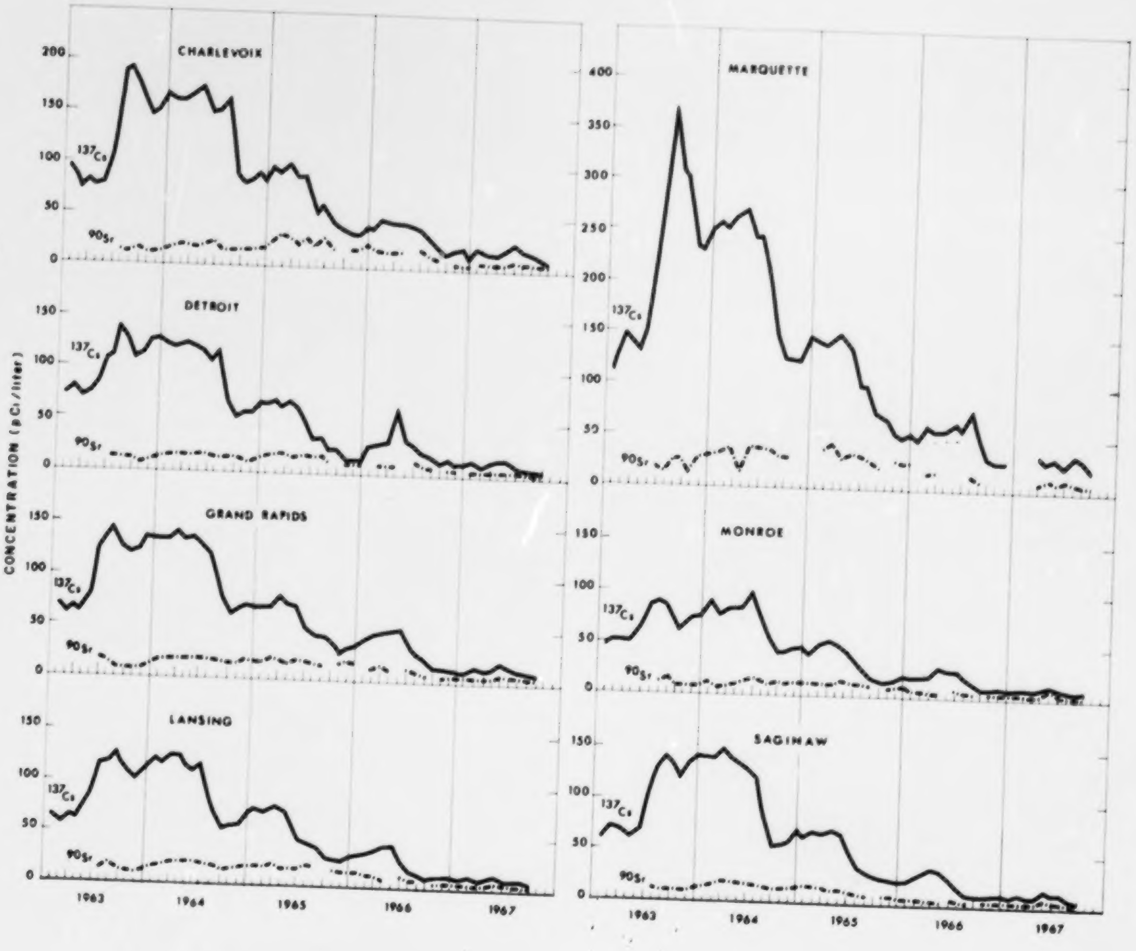

Figure 9. Radionuclide concentrations in Michigan pasteurized milk 1963–September 1967

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
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5. Minnesota Milk Network July–September 1967

Division of Environmental Health
Minnesota Department of Health

In September 1958, the Minnesota Department of Health initiated a pasteurized milk network to monitor strontium-90 concentrations. Presently, monthly samples are collected from eight sampling locations in milksheds geographically the same as the Minnesota health districts (figure 10) and analyzed for strontium-90, iodine-131, and cesium-137. One liter samples of processed Grade A fluid milk are collected at bottling machines in pasteurization plants. The samples are customarily collected in the cities where the Minnesota Health Department district offices are located. However, it is sometimes convenient to collect at other locations. Such samples are considered representative of the district concerned.

Table 6. Radionuclide concentrations in Minnesota pasteurized milk July–September 1967

Location	Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
	July	Aug	Sept	July	Aug	Sept
Bemidji	14	16	14	29	38	19
Mankato	12	6	6	14	7	3
Rochester	9	8	8	6	7	8
Duluth	24	18	17	42	49	24
Worthington	9	7	6	14	4	8
Minneapolis	16	14	12	20	19	13
Fergus Falls	11	8	8	17	4	13
Little Falls	12	12	9	19	15	15
Average	13	11	10	20	18	13

Strontium-90 concentrations are determined radiochemically while iodine-131 and cesium-137 concentrations are determined by gamma-ray scintillation spectrometry. The analytical procedures are presented in the semiannual report of the Minnesota Department of Health and the Rural Cooperative Power Association (*6*).

Strontium-90 and cesium-137 concentra-

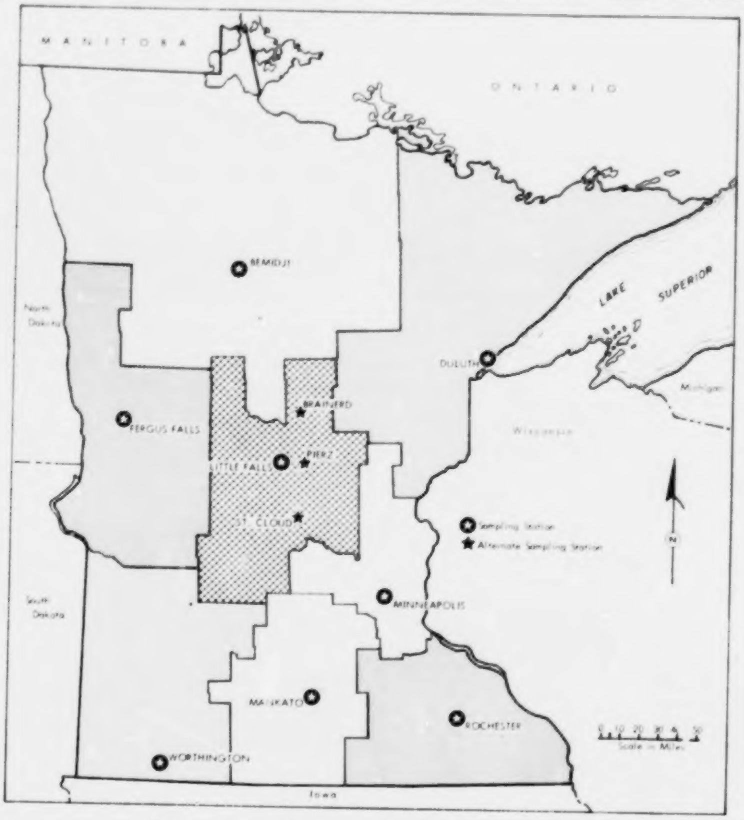

Figure 10. Minnesota milk sampling stations

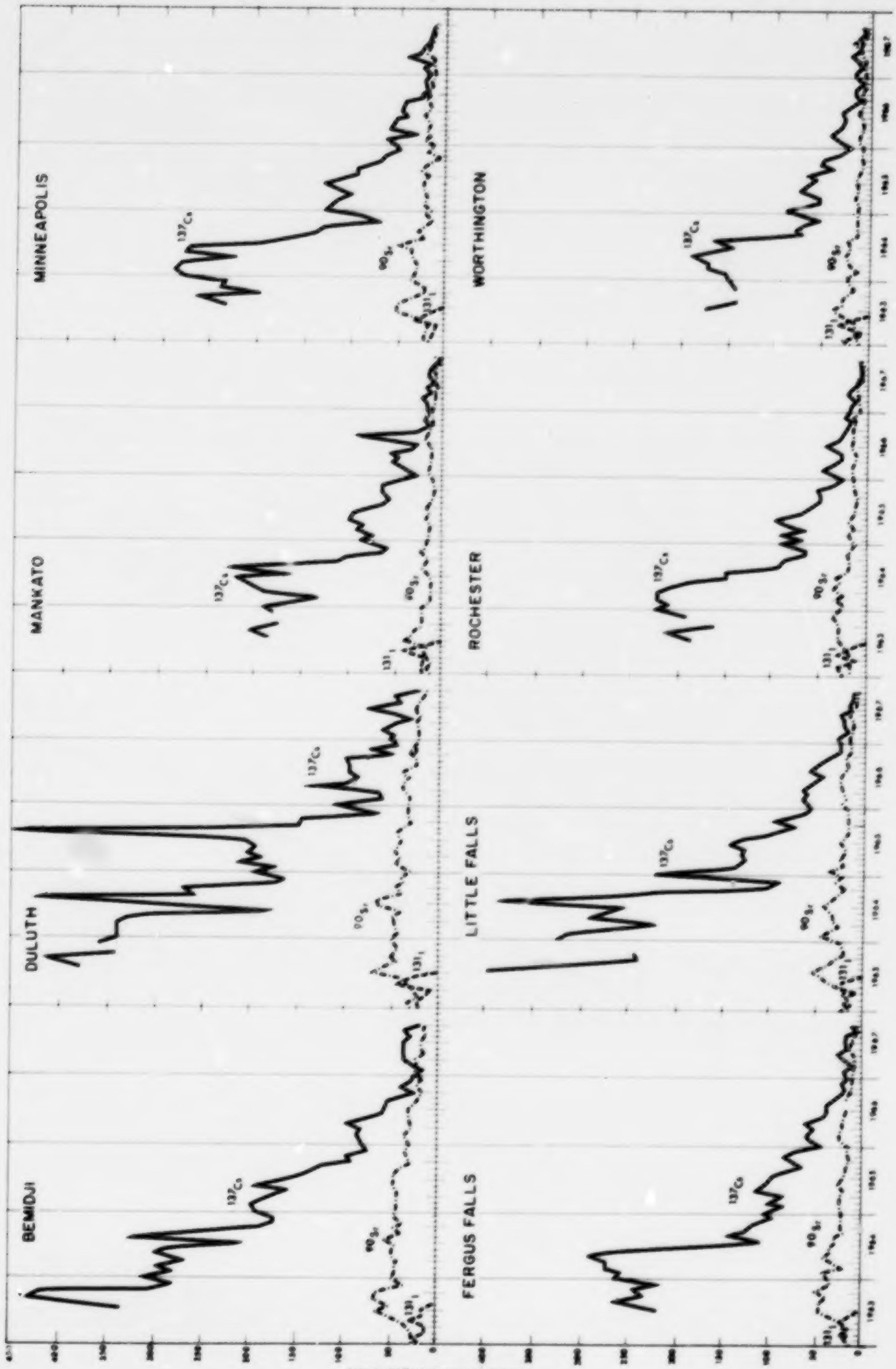

Figure 11. Radionuclide concentrations in Minnesota milk, 1963–September 1967

tions in milk are given for July through September 1967, in table 6 and are presented graphically by milkshed in figure 11 for the period 1961 through September 1967. Iodine-131 concentrations were less than 10 pCi/liter in all 24 samples.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
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April–June 1967	November 1967

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6. Pennsylvania Milk Network July–September 1967

Bureau of Environmental Health
Pennsylvania Department of Health

Samples of pasteurized milk are routinely collected from six major milk consumption areas throughout Pennsylvania (figure 14). Samples are collected weekly in Pittsburgh, while biweekly composite samples are collected from the other five stations. At each sampling location, subsamples are collected from the major dairies supplying the area and are composited in proportion to the amount of milk processed by each dairy. This composite is then sent to the Radiation Laboratory of the Division of Occupational Health in Harrisburg where the samples are analyzed for iodine-131, potassium-40, and cesium-137 and then composited for a monthly analysis of strontium-90. Strontium-90 analysis has been carried out since April 1963.

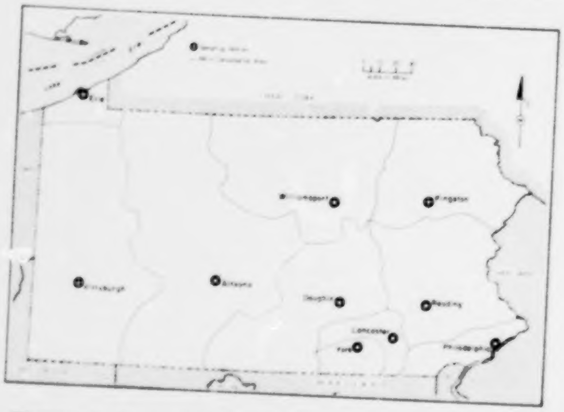

Figure 12. Pennsylvania milk network sampling stations

The monthly average potassium-40, strontium-90, iodine-131, and cesium-137 concentrations in pasteurized milk are given in table 7. For comparative purposes, strontium-90, iodine-131, and cesium-137 concentrations are presented graphically in figure 15.

The chemical separation technique for strontium-90 is essentially an ion-exchange method described by Porter, *et al* (*2*).

Table 7. Radionuclide concentrations in Pennsylvania pasteurized milk July–September 1967

Sampling location	Radionuclide concentrations (pCi/liter)											
	Potassium-40			Strontium-90			Iodine-131			Cesium-137		
	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept
Altoona	NS	1,410	1,380	NS	9	11	NS	<10	<10	NS	14	15
Dauphin	1,290	1,360	1,310	11	9	9	<10	<10	<10	14	17	11
Erie	1,350	1,425	1,390	11	13	10	<10	<10	10	27	19	17
Philadelphia	1,410	1,260	1,320	9	10	10	<10	<10	<10	15	14	17
Pittsburgh	1,330	1,390	1,490	11	13	13	<10	<10	<10	21	15	13
York	1,390	NS	NS	10	NS	NS	<10	NS	NS	16	NS	NS
Average	1,360	1,375	1,375	10	11	11	<10	<10	<10	19	16	15

NS, no sample.

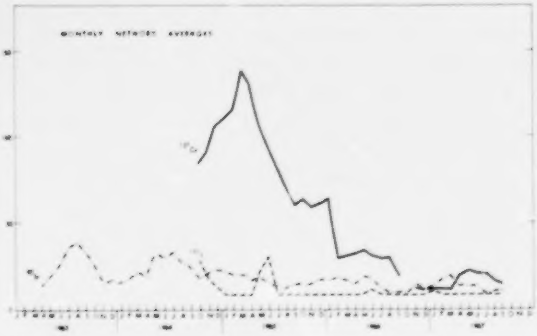

Figure 13. Radionuclide concentrations in Pennsylvania milk, 1963–September 1967

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1967	August 1967
April–June 1967	November 1967

REFERENCES

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(*5*) MICHIGAN DEPARTMENT OF HEALTH. Michigan milk network, November 1962–December 1964. Radiol Health Data 6:487–492 (September 1965).

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Periodically, results from the United Kingdom Diet Survey, conducted by the United Kingdom Agricultural Research Council Radiobiological Laboratory, are presented for comparison with data observed in the United States. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows.

Program	Period reported	Last presented
Connecticut Standard Diet	January–June 1967	November 1967
Tri-City Diet, HASL	August–December 1966	September 1967
Institutional Diet, PHS	April–June 1967	January 1968

1. Estimated daily intake of radionuclides in California diets
March–June 1967

Bureau of Radiological Health
California State Department of Public Health

Since January 1964, the Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians (*1*).

Recognizing that a "standard" or "typical" diet does not exist due to variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 20 geographic areas of interest (figure 1).

Hospitals were chosen as the source of diet samples under the hypothesis that their diets are as "reasonably representative" as any other. General hospitals exist in each of the 20 selected geographic areas and operate with trained dietitians. There is good reason to believe that hospitals utilize foods which are

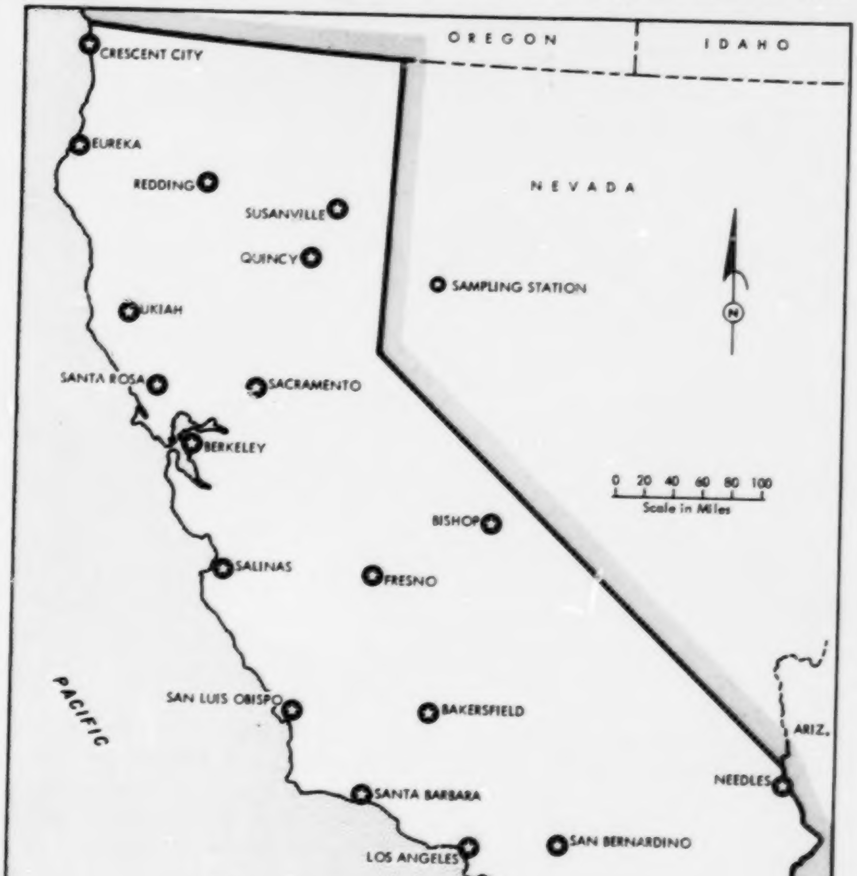

Figure 1. California diet sampling stations

marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Hospitals.

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected every 2 months at each facility. Each sample represents the edible portion of a regular meal (the standard diet) for a full 7-day week (21 consecutive meals).

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory of the State Department of Public Health. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

Analytical procedures

After weighing at the laboratory, each sample is homogenized and analyzed for gamma-ray emitters, then dried and ashed prior to analysis for strontium-89, strontium-90, radium-226, and stable calcium, strontium and sodium.

Data and discussion

The resultant estimates of daily intake of radionuclides in the California diets are given in table 1 (March-April 1967) and table 2 (May-June 1967).

It should be noted that levels of radioactivity were observed to be far below those levels for which consideration should be given to protective health action. A summary of strontium-90 and cesium-137 intake trends in California diets from January 1964 through June 1967 is given in figures 2 and 3.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January-April 1966	January 1967
May-August 1966	May 1967
September 1966-Febuary 1967	October 1967

Table 1. Estimated daily intake of radionuclides in California diets, March-April 1967[a]

City	Consumption (kg/capita • day)[b]	Intake (pCi/capita • day)							Intake (g/capita • day)			
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	^{141}Ce ^{144}Ce	K[c]	Na	Ca	Stable strontium
Bakersfield	2.1	0	5	0.7	9	1	0	0	2.0	3.1	0.9	0.003
Berkeley	2.2	[d] 2	4	0.9	26	0	0	0	2.1	3.1	0.8	.003
Bishop	1.7	[d] 2	5	0.7	11	4	0	0	2.4	3.0	0.7	.002
Brawley	1.8	3	5	0.9	9	0	0	0	2.0	3.0	0.6	.003
Crescent City	2.0	13	12	0.9	24	7	0	0	2.3	4.1	0.9	.003
Eureka	2.2	0	7	0.8	21	7	0	0	2.1	4.7	0.7	.004
Fresno	2.2	[d] 1	5	1.2	16	1	0	0	2.0	3.2	0.6	.002
Los Angeles (Santa Monica)	1.9	[d] 3	9	0.8	13	2	0	0	2.2	3.7	0.7	.004
Needles	2.2	0	5	1.1	14	3	0	0	2.3	3.7	0.7	.004
Quincy	2.4	0	10	0.8	17	1	0	0	2.8	4.0	0.8	.002
Redding	2.2	[d] 2	9	1.6	20	3	0	0	2.8	4.4	0.8	.003
Sacramento	2.4	6	9	1.4	18	2	0	0	2.3	4.0	1.3	.003
Salinas	2.3	7	3	1.4	15	0	0	0	2.6	5.1	0.7	.004
San Bernardino	1.6	0	7	0.1	6	2	0	0	1.9	3.0	0.8	.002
San Diego	([e])											
San Luis Obispo	1.3	[d] 2	6	0.6	11	1	0	0	1.6	3.8	0.8	.003
Santa Barbara	2.1	[d] 4	5	0.9	11	3	0	0	2.3	3.4	0.9	.004
Santa Rosa	1.7	4	7	0.6	13	1	2	0	1.7	2.3	1.0	.003
Susanville	1.9	[d] 1	5	0.5	20	1	0	0	2.1	3.6	0.7	.003
Ukiah	2.5	0	4	1.1	18	0	0	0	2.1	4.0	1.0	.003

[a] Based on analyses of Hospital Standard Diets located in listed cities.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 pecent radioactive potassium-40.
[d] When the counting rate of the sample is not equal to at least twice the 0.95 error the value reported is the best available estimate but is not statistically significant.
[e] Sample lost.

Table 2. Estimated daily intake of radionuclides in California diets, May–June 1967[a]

City	Consumption (kg/capita • day) [b]	Intake (pCi/capita • day)								Intake (g/capita • day)			
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{140}Ba-La	^{95}Zr	^{54}Mn	^{141}Ce ^{144}Ce	K[c]	Na	Ca	Stable strontium
Bakersfield	2.1	[d] 3	4	1.1	12	[d] 13	[d] 2	0	0	2.6	4.0	1.1	0.004
Berkeley	1.6	[d] 2	4	0.5	11	0	1	0	0.2	1.5	2.2	0.4	.003
Bishop	2.4	[d] 3	6	0.7	16	0	[d] 5	0	0	3.0	3.7	0.7	.004
Brawley	1.8	[d] 1	5	1.3	12	37	0	0	0	1.6	3.1	NA	.003
Crescent City	2.1	9	12	0.8	23	0	[d] 4	0	0	2.8	3.3	0.8	.005
Eureka	2.1	3	8	0.6	9	0	[d] 3	0	0	2.3	4.2	0.6	.004
Fresno	2.3	[d] 3	5	1.5	20	0	0	0	0	2.0	2.6	0.7	.003
Los Angeles	2.4	[d] 2	9	1.3	21	0	6	0	0	2.5	4.4	1.2	.005
Needles	2.5	[d] 1	6	1.6	14	[d] 4	3	0	0	2.5	3.4	1.0	.006
Quincy	2.2	[d] 2	8	0.7	12	0	[d] 4	0	0	2.5	3.0	1.0	.003
Redding	2.3	[d] 2	8	1.6	19	0	[d] 4	0	0	2.6	3.4	0.8	.003
Sacramento	2.5	[d] 1	9	1.4	25	72	0	0	0	2.8	5.0	NA	.001
Salinas	2.3	[d] 4	5	1.2	17	0	[d] 4	0	0	2.5	5.5	0.6	.004
San Bernardino	1.7	3	2	1.0	15	0	0	0	0	2.0	2.9	0.6	.004
San Diego	1.6	2	3	0.4	22	0	0	0	0	1.4	2.4	0.5	.003
San Luis Obispo	1.2	[d] 2	5	1.1	10	1	2	0	0	1.6	3.2	0.7	.003
Santa Barbara	2.0	[d] 3	5	0.8	8	0	[d] 4	0	0	3.0	4.4	1.1	.007
Santa Rosa	1.9	[d] 2	5	1.0	7	0	[d] 2	0	0	1.7	2.6	0.8	.004
Susanville	1.9	3	5	0.6	14	0	[d] 3	0	0	2.7	2.6	0.6	.004
Ukiah	2.3	8	9	1.0	20	11	1	0	0	2.3	4.2	1.3	.004

[a] Based on analyses of Hospital Standard Diets located in listed cities.

[b] Kilograms of food per person per day in this diet.

[c] Natural potassium contains 0.0119 percent radioactive potassium-40.

[d] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant.

NA, no analysis.

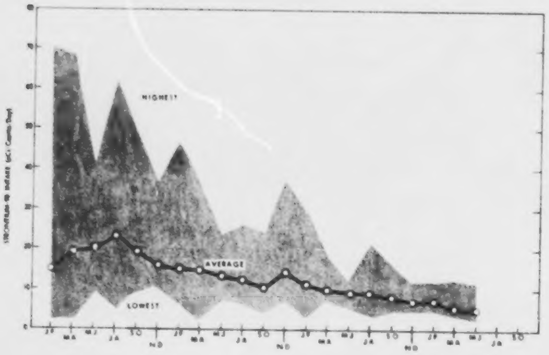

Figure 2. Averages and ranges of daily strontium-90 intake in California diets, 1964–June 1967

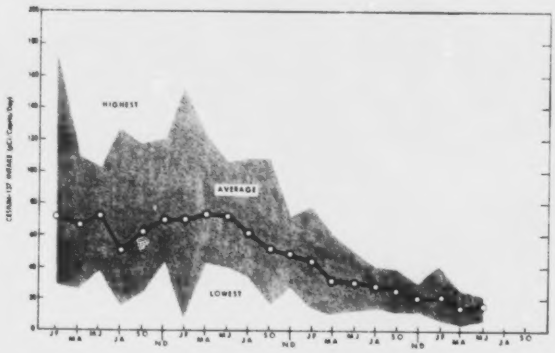

Figure 3. Averages and ranges of daily cesium-137 intake in California diets, 1964–June 1967

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SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*), set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium–90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

Activity	Period reported	Last presented
Coast Guard Water Sampling Program	January–December 1966	November 1967
Minnesota Municipal Water	January–June 1967	January 1968
New York Surface Water	January–June 1966	September 1967
Radiostrontium in Tap Water, HASL	July–December 1966	November 1967
Washington Surface Water Sampling	July 1965–June 1966	August 1967

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium–90, respectively.

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(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

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Gross Radioactivity in Surface Waters of the United States, August 1967

Division of Pollution Surveillance, Federal
Water Pollution Control Administration,
Department of Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the August 1967 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1-6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radio-

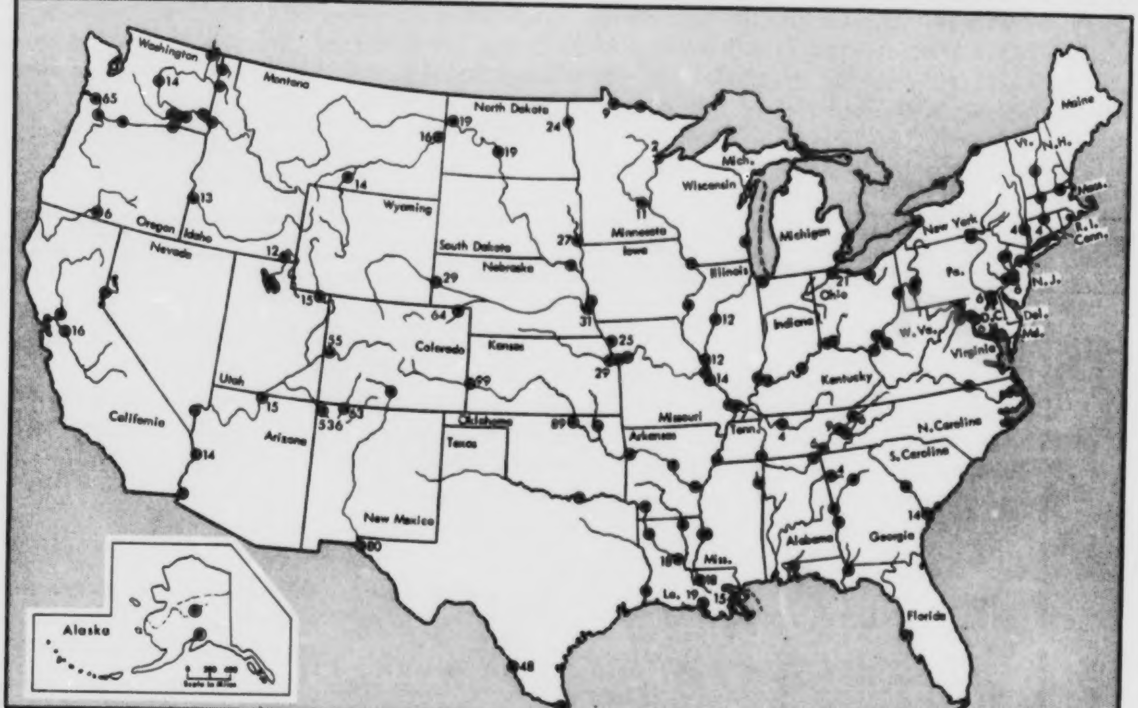

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, August 1967

Table 1. Radioactivity in raw surface waters, August 1967

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex	16	2	18	54	9	63
Arkansas River:						
Coolidge, Kans	30	15	45	64	35	99
Ponca City, Okla	8	7	15	73	16	89
Atchafalaya River:						
Morgan City, La	3	3	6	12	7	19
Bear River:						
Preston, Idaho	1	4	5	0	12	12
Big Horn River:						
Hardin, Mont	1	2	3	1	13	14
Big Sioux River:						
Sioux Falls, S. Dak	2	4	6	5	22	27
Clinch River:						
Clinton, Tenn	1	0	1	3	3	6
Kingston, Tenn [a]	0	<1	<1	1	8	9
Colorado River:						
Loma, Colo	12	6	18	34	21	55
Page, Ariz	0	6	6	<1	15	15
Parker Dam, Calif-Ariz	0	3	3	0	14	14
Columbia River:						
Wenatchee, Wash	0	7	7	0	14	14
Clatskanie, Ore	<1	0	<1	18	47	65
Connecticut River:						
Enfield Dam, Conn	0	0	0	1	3	4
Coosa River:						
Rome, Ga	<1	0	<1	2	2	4
Cumberland River:						
Cheatham Lock, Tenn	1	0	1	1	3	4
Delaware River:						
Philadelphia, Pa	0	1	1	2	4	6
Great Lakes:						
Duluth, Minn	1	1	2	0	2	2
Green River:						
Dutch John, Utah	<1	5	5	0	15	15
Hudson River:						
Poughkeepsie, N. Y	0	1	1	0	4	4
Illinois River:						
Peoria, Ill	1	7	8	3	9	12
Grafton, Ill	1	4	5	3	9	12
Kansas River:						
DeSoto, Kans	4	4	8	14	15	29
Klamath River:						
Keno, Ore	0	0	0	<1	6	6
Maumee River:						
Toledo, Ohio	1	3	4	2	19	21
Mississippi River:						
St. Paul, Minn	1	5	6	1	10	11
E. St. Louis, Ill	2	1	3	3	11	14
New Roads, La	4	2	6	8	10	18
New Orleans, La	1	3	4	7	8	15
Missouri River:						
Williston, N. Dak	3	4	7	8	11	19
Bismarck, N. Dak	1	4	5	4	15	19
St. Joseph, Mo	3	4	7	10	15	25
North Platte River:						
Henry, Nebr	3	12	15	7	21	29
Ohio River:						
Cairo, Ill	0	2	2	2	5	7
Platte River:						
Plattsmouth, Nebr	4	6	10	10	21	31
Potomac River:						
Washington, D. C.	0	1	1	1	5	6
Rainy River:						
Baudette, Minn	0	0	0	1	8	9
Red River, North:						
Grand Forks, N. Dak	1	4	5	2	22	24
Red River, South:						
Alexandria, La	1	4	5	2	16	18
Rio Grande:						
El Paso, Tex	19	3	22	67	13	80
Laredo, Tex	10	3	13	38	10	48
San Joaquin River:						
Vernalis, Calif	3	2	5	9	7	16
San Juan River:						
Shiprock, N. Mex	239	4	243	517	19	536
Savannah River:						
Port Wentworth, Ga [a]	<1	1	1	4	10	14
Snake River:						
Payette, Idaho	1	5	6	5	8	13
South Platte River:						
Julesburg, Colo	2	21	23	6	58	64
Susquehanna River:						
Conowingo, Md	1	1	2	2	4	6
Tennessee River:						
Chattanooga, Tenn	1	<1	1	2	4	6
Yellowstone River:						
Sidney, Mont	2	3	5	5	11	16
Maximum	239	21	243	517	58	536
Minimum	0	0	0	0	2	2

[a] Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

activity per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations of the Water Pollution Surveillance System for 1961 through 1965 has been presented (7). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During July and August, the following stations showed values in excess of 15 pCi/liter on alpha radioactivity for either suspended or dissolved solids:

San Juan River; Shiprock, N. Mex.
South Platte River; Julesburg, Colo.
Arkansas River; Coolidge, Kans.

During August, Cedar Hill, N. Mex. on the Animas River and El Paso, Tex., on the Rio Grande showed values in excess of 15 pCi/liter on alpha radioactivity for suspended solids.

The following stations decreased to less than 15 pCi/liter on alpha radioactivity for either suspended or dissolved solids:

Rio Grande; Laredo, Tex.
Yellowstone River; Sidney, Mont.

Shiprock, N. Mex., on the San Juan River showed a suspended beta radioactivity in excess of 150 pCi/liter. This high value is due to a correspondingly high level of suspended solids.

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(2) *Ibid.*, 1959 Edition.
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(4) *Ibid.*, 1961 Editon.
(5) *Ibid.*, 1962 Edition.
(6) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(7) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961–1965. Radiol Health Data Rep 9:1–12 (January 1968).

Radioactivity in California Waters[1], July–December 1966

Bureau of Radiological Health,
State of California
Department of Public Health

Gross beta radioactivity in California domestic waters is monitored by the State of California's Bureau of Radiological Health. The importance of this program in the State's environmental surveillance activities, stems from the fact that most of California's domestic water supplies are of surface origin.

Radioactivity in such water supplies consists of the natural radioactivity in surface streams, radioactivity added by the discharge of sewage or by industrial waste effluents, and radioactivity from fallout, particularly fallout into open terminal or distribution reservoirs. Present efforts consist of sampling raw and treated surface waters and well waters. It should be noted that except for large metropolitan water supplies, raw water sampling is being phased out and treated water sampling substituted or continued. This procedural change is predicated upon sampling water at the point of consumption.

Most of the supplies sampled have, as a source, raw surface waters (figure 1), although a few wells, along with some water supplies that use infiltration galleries, are also sampled.

Monitoring of domestic water supplies is on a continuing basis, since it has not been possible to forecast levels of radioactivity in these supplies based upon levels in rain, snow, or surface streams. Under the present sampling schedule, monthly 500 ml samples are collected and the total solids analyzed for alpha and beta radioactivity. In addition, 3-liter samples are collected monthly for approximately 6 months and composited for specific radionuclide analysis on a semiannual basis.

Analytical procedures

Radionuclide analyses of water are carried out in the State's Sanitation and Radiation Laboratory. Measurements of alpha and alpha-plus-beta radioactivities are made with a low-background windowless gas-flow proportional counter. Counting methods used follow those recommended by the U.S. Public Health Service (*1*).

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[1] Data from January and April 1967 issues of Radiological Health News, State of California, Department of Public Health, Bureau of Radiological Health, 2151 Berkeley Way, Berkeley, Calif. 94704.

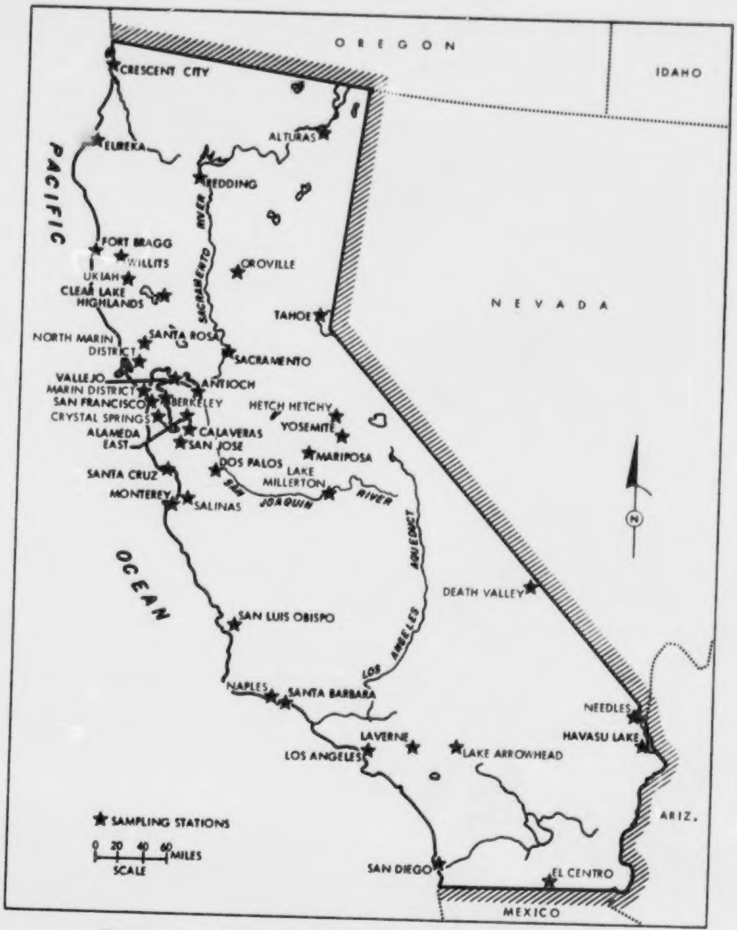

Figure 2. California surface water sampling stations

Individual samples are evaporated to dryness and the residue ashed at 450°C. The ashed sample is dissolved and transferred to an aluminum planchet for beta-particle counting. Radioisotopic analyses are determined semiannually on composite samples. Gamma-ray emitting nuclides are determined by gamma-ray spectroscopy and radium and radiostrontium by chemical separation and counting.

Discussion

Table 1 shows the monthly average beta radioactivity in the suspended-plus-dissolved solids in surface water supplies in California from July through December 1966. Following treatment, these waters are used for industrial and domestic purposes. Because alpha radioactivity in water has, in general, been undetectable or very slight, alpha radioactivity analyses are not presented. No increase in radioactivity level of surface water has been observed.

Table 2 shows specific radionuclide concentrations in California surface waters for 1965 through June 1966 by stations.

Table 1. Gross beta radioactivity in California domestic waters, July–December 1966

Sampling station	Quality	Concentration (pCi/liter)					
		July	August	September	October	November	December
Alturas	Well	NS	NS	NS	NS	[a] 16	NS
Antioch	Treated	[a] 9	[a] 1	ND	[a] 5	32	[a] 2
Lake Arrowhead	Treated	NS	[a] 13	[a] 10	[a] 1	[a] 2	NS
Berkeley	Treated	ND	ND	[a] 9	[a] 3	[a] 11	[a] 17
Clearlake Highlands	Treated	[a] 3	[a] 9	[a] 11	[a] 4	[a] 9	[a] 6
Crescent City	Well	[a] 8	[a] 8	[a] 7	[a] 5	[a] 16	ND
Death Valley	Treated	42	[a] 10	[a] 2	[a] 4	[a] 8	[a] 6
Dos Palos	Treated	ND	ND	ND	[a] 10	ND	ND
El Centro	Treated	[a] 3	[a] 10	[a] 10	[a] 19	ND	[a] 24
Eureka	Raw	[a] 7	ND	ND	ND	[a] 21	ND
Los Angeles Laboratory	Treated	[a] 20	ND	[a] 6	[a] 3	ND	ND
	Raw	[a] 7	[a] 24	[a] 6	[a] 14	[a] 2	NS
Marin Municipal Water District	Treated	ND	[a] 12	[a] 4	[a] 6	[a] 11	ND
Mariposa	Treated	[a] 6	[a] 9	[a] 5	NS	ND	[a] 12
Metropolitan Water District of Southern California:							
Lake Havasu	Raw	40	[a] 3	NS	[a] 5	[a] 14	[a] 5
Weymouth Plant	Treated	[a] 14	[a] 23	[a] 16	[a] 24	[a] 6	[a] 15
Lake Millerton	Raw	ND	ND	[a] 2	[a] 11	[a] 25	[a] 4
Monterey	Treated	NS	ND	NS	NS	ND	ND
Napa	Treated	[a] 7	[a] 17	ND	ND	ND	[a] 7
Needles	Well	[a] 14	[a] 18	[a] 52	[a] 41	ND	ND
North Marin Water District	Treated	[a] 8	[a] 17	[a] 8	[a] 18	ND	[a] 19
	Raw	[a] 7	[a] 11	ND	ND	[a] 21	31
	Sludge [b]	[a] 2	[a] 1	[a] 17	171	ND	[a] 59
Oroville:							
California Water Service	Treated	[a] 16	[a] 18	NS	[a] 1	NS	NS
Wyandotte Irrigation District	Treated	[a] 17	ND	NS	NS	[a] 6	NS
Pleasanton	Well	ND	[a] 6	ND	ND	[a] 1	[a] 17
Redding	Treated	[a] 3	NS	[a] 9	ND	[a] 2	NS
Sacramento	Treated	NS	[a] 9	ND	[a] 3	[a] 3	9
Salinas	Well	NS	NS	NS	ND	NS	NS
San Diego	Raw	[a] 17	[a] 15	[a] 2	ND	[a] 22	NS
	Treated	[a] 9	ND	[a] 3	[a] 28	[a] 17	NS
San Francisco:							
Water Department	Raw	[a] 1	[a] 3	ND	[a] 22	ND	[a] 3
Alameda, East	Raw	ND	[a] 14	[a] 3	ND	ND	ND
Brightside Weir	Raw	ND	[a] 17	[a] 1	[a] 7	[a] 1	[a] 1
Calaveras Reservoir	Raw	ND	[a] 15	[a] 3	[a] 19	ND	[a] 3
Crystal Springs	Raw	ND	ND	ND	ND	[a] 2	[a] 5
Hetch Hetchy	Raw	[a] 3	[a] 2	ND	[a] 2	[a] 1	[a] 6
San Jose	Raw	ND	ND	ND	NS	ND	NS
Santa Barbara	Treated	[a] 12	[a] 3	ND	[a] 15	[a] 7	[a] 5
Santa Rosa	Raw	ND	ND	[a] 7	[a] 8	[a] 1	ND
Tahoe City	Raw	ND	[a] 4	[a] 2	ND	NS	NS
Ukiah	Well	ND	[a] 6	NS	NS	ND	ND
Vallejo:							
Fleming Hill	Raw	[a] 2	[a] 1	[a] 21	[a] 18	ND	[a] 5
	Treated	ND	[a] 9	[a] 10	ND	ND	ND
Swanzy Reservoir	Treated	ND	ND	[a] 23	[a] 3	[a] 9	[a] 6
Yosemite	Treated	[a] 5	[a] 7	ND	[a] 12	ND	[a] 7
Maximum		42	24	52	171	32	59
Minimum		1	1	1	1	1	1

[a] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best estimate but is not statistically significant.

[b] Sludge reported in pCi/g (dry weight).

NS, no sample collected.

ND, no detectable radioactivity.

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(1) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclide analyses of environmental samples, R 59-6. Radiological Health Research Activities, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio 45226 (November 16, 1959).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1965	November 1966
January–June 1966	June 1967

Table 2. Radionuclide concentrations in California surface water, 1966

Sampling station and date 1966	Concentration (pCi/liter)				
	Radium-226	Barium-lanthanum-140	Strontium-90	Strontium-89	Potassium-40
Antioch:					
January-June	0.05	NA	1	ND	[a] 1
Berkeley:					
January-June	0.01	[a] 34	1	ND	[a] 1
Dos Palos:					
March-August	0.14	[a] 11	ND	ND	[a] 2
El Centro:					
January-June	0.22	[a] 310	[a] 1	[a] 2	[a] 6
Lake Millerton:					
January-June	[a] 0.02	ND	[a] 1	NA	ND
Metropolitan Water District of Southern California:					
Weymouth Plant:					
January-June	NA	[a] 154	[a] 1	ND	[a] 4
Monterey:					
February-August	NA	ND	ND	ND	[a] 1
Napa:					
January-June	NA	ND	1	1	[a] 2
Needles:					
January-June	[a] 0.02	ND	ND	[a] 1	[a] 10
North Marin Water District:					
January-June	[a] 0.01	[a] 11	NA	NA	[a] 5
Oroville California Water Service:					
January-June	0.03	[a] 17	ND	ND	[a] 1
Wyandotte Irrigation District:					
January-June	ND	[a] 36	[a] 1	ND	ND
Redding:					
January-June	[a] 0.01	ND	ND	ND	[a] 2
Sacramento:					
April-September	NA	NA	NA	NA	[a] 2
San Diego:					
January-June	[a] 0.04	[a] 146	[a] 2	ND	[a] 4
San Jose:					
June-August 1965 [b]	NA	ND	ND	NA	[a] 1
January-June	[a] 0.03	ND	ND	[a] 1	[a] 2
Santa Barbara:					
January-June	0.08	[a] 15	[a] 1	ND	[a] 1
Santa Cruz:					
July-December 1965 [b]	0.04	ND	[a] 1	ND	[a] 2
January-June	[a] 0.02	[a] 33	[a] 1	ND	[a] 2
Santa Rosa:					
January-June	0.04	ND	ND	ND	[a] 2
Tahoe City:					
January-June	[a] 0.02	ND	NA	NA	[a] 1
Vallejo:					
May-June	0.01	[a] 4	[a] 1	ND	[a] 2
Yosemite:					
January-June	NA	3	[a] 1	ND	ND

Results for manganese-54, iodine-131 and cerium-141-144 for all stations were non-detectable during this period except for a value of [a]1 pCi/liter for zirconium-niobium-95 and ruthenium-rhodium-106 at Needles and [a]1 pCi/liter for cesium-137 at San Diego.

[a] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant.

[b] Data not previously reported.

NA, no analysis.

ND, no detectable activity.

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SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-particle analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data.* In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
HASL Fallout Network	July–December 1966	September 1967
HASL 80th Meridian Network	Calendar Year 1965	January 1967
Plutonium in Airborne Particulates	January–March 1967	September 1967

1. Radiation Surveillance Network
October 1967

National Center for Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples at 73 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples if airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Md., for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta radioactivity by the station operators. These estimates are made after the decay of radon and partial decay of thoron daughter products and prior to submission of the samples for laboratory analysis. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*1*). A detailed description of the sampling and analytical procedures was presented in the November 1966 issue of *Radiological Health Data and Reports*. The described procedures have been modified in that laboratory gross beta-particle counting and gamma-ray spectroscopy are no longer performed on air samples having a field estimate below 10 pCi/m^3. Reporting field estimates only may cause an apparent increase in the published airborne radioactivity levels proportional to the amount of thoron daughter radioactivity present in the sample. In extreme cases, this increase may be as much as 2 orders of magnitude, but usually will be of the order of a factor of 2 or less. The maximum field estimates reported by RSN stations and attributable to thoron daughter radioactivity have ranged from 15 to 20 pCi/m^3 at 5 hours after collection.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates as measured by the field estimates, and deposition by precipitation during October 1967. Time profiles of gross beta radioactivity in air for eight RSN stations are shown in figure 2.

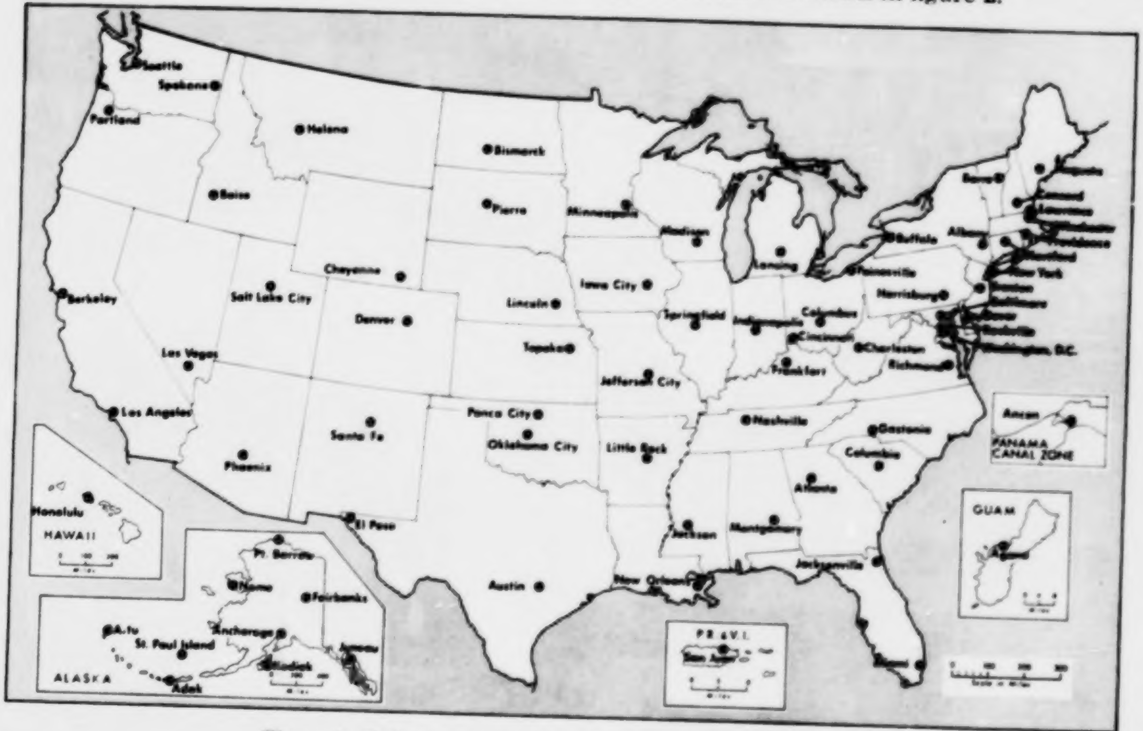

Figure 1. Radiation Surveillance Network sampling stations

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Table 1. Gross beta radioactivity in surface air and precipitation, October 1967

Station location		Number of samples		Air surveillance, gross beta radioactivity (pCi/m³)			Last profile in *RHD&R*	Precipitation	
		Air	Pptn	Maximum	Minimum	Average[a]		Total depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	31	3	10.53	0.42	3.72	Nov 67	72	<14
Alaska:	Adak	30		0.40	.36	0.36	June 67	[c]	
	Anchorage	21	3	.00	.00	.00	Dec 67	8	< 2
	Attu Island	6		.00	.00	.00	July 67	[c]	
	Fairbanks	[b]					Jan 68	[c]	
	Juneau	18	13	.36	.00	.02	Feb 68	222	<44
	Kodiak	10		1.40	.35	.56	May 67	[c]	
	Nome	31		1.16	.00	.44	Sept 67	[c]	
	Pt. Barrow	31		1.27	.59	.67	Aug 67	[c]	
	St. Paul Island	4		.90	.45	.57	Oct 67	[c]	
Ariz:	Phoenix	17		7.49	.20	2.74	Feb 68	[c]	
Ark:	Little Rock	15	2	2.76	.32	1.01	Dec 67	64	<13
Calif:	Berkeley	20	1	3.63	.00	.70	May 67	12	< 2
	Los Angeles	21		2.34	.26	1.09	Sept 67	[c]	
C. Z:	Ancon	17		1.88	.92	1.43	May 67	[c]	
Colo:	Denver	21		6.60	.67	2.87	May 67	[c]	
Conn:	Hartford	20	4	.97	.22	.33	Jan 68	64	<13
Del:	Dover	21		1.41	.19	.44	Nov 67	[c]	
D. C:	Washington	30	6	3.24	.27	1.03	Aug 67	49	<10
Fla:	Jacksonville	22	4	1.71	.35	.53	Dec 67	17	< 4
	Miami	14	11	.23	.06	.12	Jan 68	245	<49
Ga:	Atlanta	21	4	1.51	.35	.85	Oct 67	87	<18
Guam:	Agana	17		1.03	.00	.54	Nov 67	[c]	
Hawaii:	Honolulu	31		.86	.31	.44	July 67	[c]	
Idaho:	Boise	26	5	4.90	.63	2.34	July 67	26	< 5
Ill:	Springfield	19	2	3.18	.32	.83	Aug 67	18	< 4
Ind:	Indianapolis	21	8	2.07	.84	1.24	Oct 67	141	<28
Iowa:	Iowa City	17	6	2.33	.53	1.34	May 67	160	<32
Kans:	Topeka	19	8	3.10	.27	.98	Dec 67	105	<21
Ky:	Frankfort	20	5	2.86	.38	1.26	Aug 67	34	< 7
La:	New Orleans	22		.90	.07	.30	Aug 67	[c]	
Maine:	Augusta	21	8	1.29	.16	.48	Feb 68	88	<18
Md:	Baltimore	21	3	2.99	.26	1.09	Jan 68	25	< 5
	Rockville	3		3.24	.34	.96	July 67	[c]	
Mass:	Lawrence	21	7	3.15	.00	.75	Nov 67	42	< 9
	Winchester	21	7	1.79	.00	.63	June 67	35	< 7
Mich:	Lansing	22	11	3.46	.51	1.36	July 67	112	<22
Minn:	Minneapolis	19	4	.57	.19	.23	Nov 67	42	< 8
Miss:	Jackson	20	3	4.28	.19	1.17	Feb 68	49	<10
Mo:	Jefferson City	21	7	1.47	.18	.41	Oct 67	131	<26
Mont:	Helena	20	6	2.63	.24	.79	June 67	28	< 6
Nebr:	Lincoln	20	7	2.71	.52	1.24	Oct 67	19	< 4
Nev:	Las Vegas	26		2.32	.45	.90	Jan 68	[c]	
N. H:	Concord	21		2.50	.00	.92	Aug 67	[c]	
N. J:	Trenton	19	2	1.12	.16	.35	Feb 68	14	< 3
N. Mex:	Santa Fe	20	1	1.25	.16	.73	June 67	7	< 1
N. Y:	Albany	21	5	1.16	.17	.61	Oct 67	60	<12
	Buffalo	13		.36	.08	.19	May 67	[c]	
	New York City	21		.52	.15	.24	June 67	[c]	
N. C:	Gastonia	17		11.50	1.45	6.64	May 67	[c]	
N. Dak:	Bismarck	21	5	2.70	.34	1.19	Aug 67	57	<11
Ohio:	Cincinnati	20		4.95	.40	1.45	Nov 67	[c]	
	Columbus	21	3	3.55	.17	.80	Feb 68	33	< 7
	Painesville	18	12	1.54	21	.54	Jan 68	70	<14
Okla:	Oklahoma City	19		.67	.00	.26	July 67	[c]	
	Ponca City	23	5	6.46	.08	.83	Jan 68	66	<13
Ore:	Portland	21	11	1.77	.00	.41	Oct 67	101	<20
Pa:	Harrisburg	20	1	4.02	.57	1.27	Oct 67	39	< 8
P. R:	San Juan	10	2	.00	.00	.00	Feb 68	63	<13
R. I:	Providence	21	5	1.92	.00	.36	July 67	90	<18
S. C:	Columbia	9	3	1.25	.27	.52	June 67	11	< 2
S. Dak:	Pierre	13		8.10	1.21	2.36	Feb 68	[c]	
Tenn:	Nashville	17	5	3.30	.30	1.40	July 67	38	< 8
Tex:	Austin	22		7.72	.12	2.26	Nov 67	[c]	
	El Paso	31	1	6.35	.41	3.63	Aug 67	2	< 1
Utah:	Salt Lake City	31	3	1.29	.24	.70	Sept 67	27	< 5
Vt:	Barre	21	9	2.27	.21	.57	Dec 67	104	<21
Va:	Richmond	17	5	1.52	.21	.78	Dec 67	37	< 8
Wash:	Seattle	[b]					Dec 67	[c]	
	Spokane	20	7	3.75	.53	1.50	Nov 67	21	< 4
W. Va:	Charleston	21	7	2.09	.24	.83	June 67	43	< 9
Wis:	Madison	21	9	1.67	.07	.53	Dec 67	133	<27
Wyo:	Cheyenne	22	1	4.91	.69	1.72	Jan 68	12	3
Network summary		1,419	253	11.50	0.00	1.01		62	<13

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.

[b] Indicates no report received. (The data program does not distinguish between samples received without field estimate data and samples not received at all.)

[c] Indicates no precipitation sample collected.

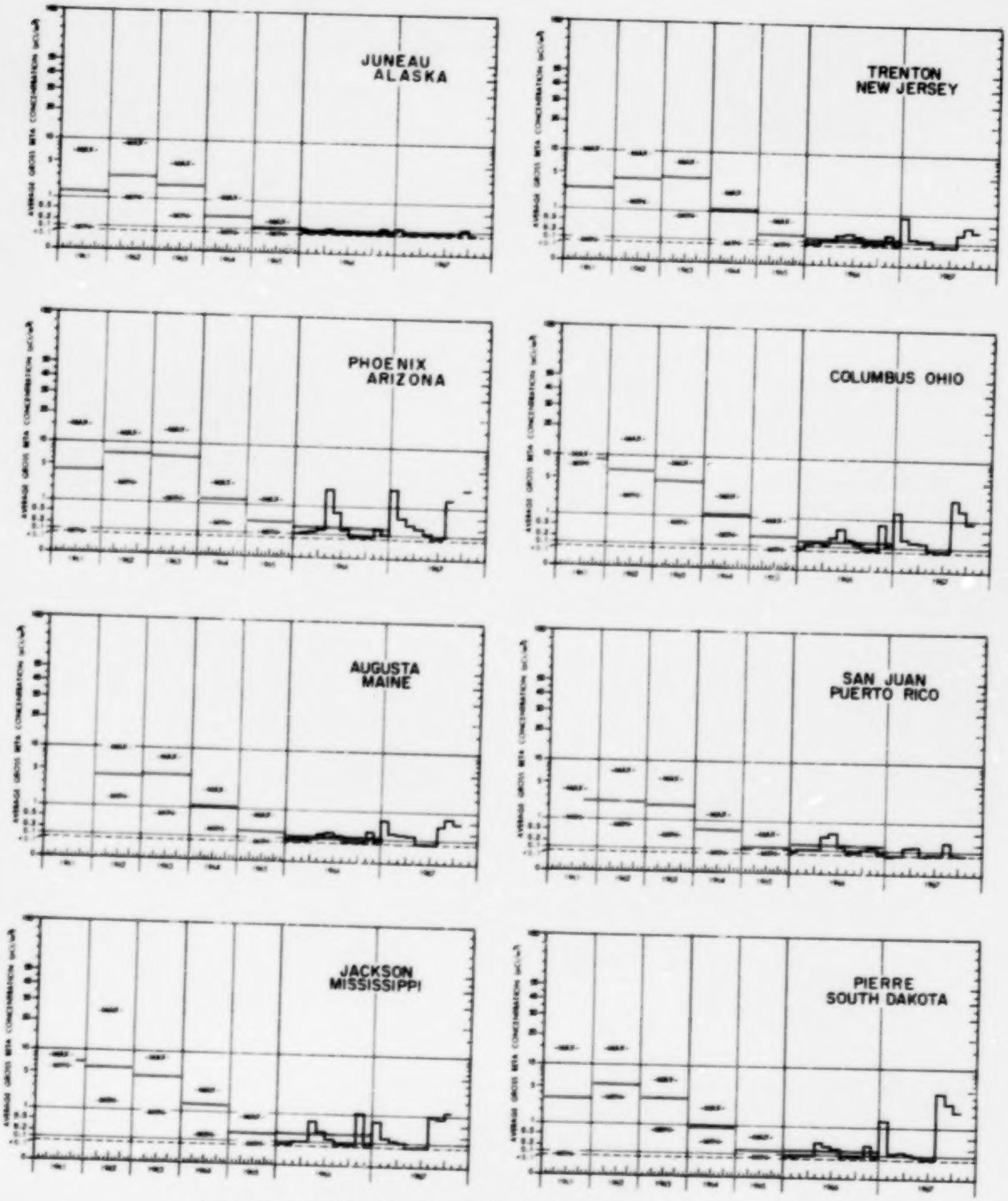

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Surveillance Network, 1961-October 1967

2. Canadian Air and Precipitation Monitoring Program October 1967[1]

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

A summary of the sampling procedures and methods of analysis was presented in the November 1966 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for October 1967 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, October 1967

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m²)
Calgary	31	0.7	0.0	0.1	.4	20
Coral Harbour	29	.3	.0	.0	.1	3
Edmonton	31	.8	.0	.0	.4	11
Ft. Churchill	31	.4	.0	.0	.2	6
Ft. William	31	.0	.0	.0	1.0	21
Fredericton	21	.2	.0	.0	.6	12
Goose Bay	31	.0	.0	.0	.3	9
Halifax	31	.2	.0	.0	.5	3
Inuvik	31	.0	.0	.0	1.1	33
Montreal	31	.4	.0	.0	.7	10
Moosonee	31	1.5	.0	.1	.4	9
Ottawa	31	.0	.0	.0	.9	10
Quebec	31	.1	.0	.0	1.7	13
Regina	31	.1	.0	.0	.5	12
Resolute	31	.0	.0	.0	NS	NS
St. John's, Nfld	31	.4	.0	.0	1.2	10
Saskatoon	31	.3	.0	.0	.7	23
Sault Ste. Marie	31	.0	.0	.0	2.2	20
Toronto	31	.4	.0	.0	.8	14
Vancouver	31	.1	.0	.0	1.4	5
Whitehorse	31	.0	.0	.0	.1	9
Windsor	31	.4	.0	.0	1.1	11
Winnipeg	31	.6	.0	.1	1.0	22
Yellowknife	29	.0	.0	.0	.7	7
Network summary	740	1.5	0.0	0.0	0.8	13

NS, no sample.

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[1] Prepared from information and data in the November 1967 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

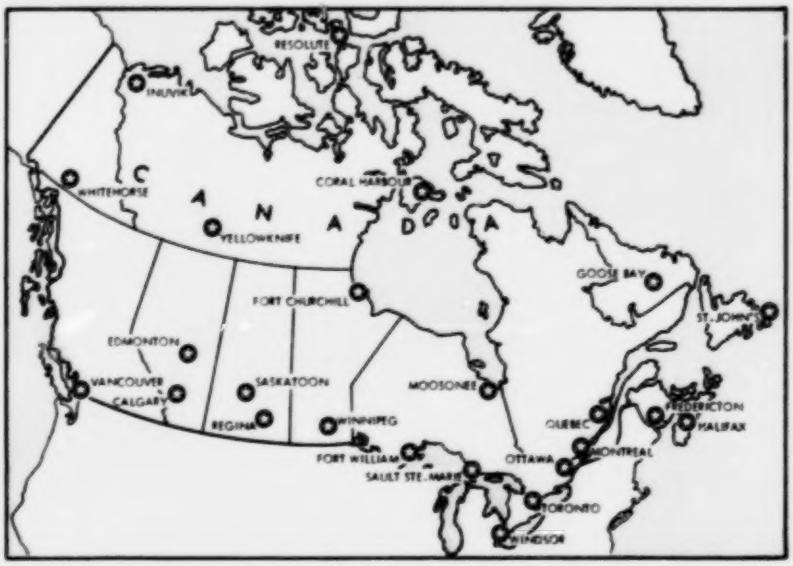

Figure 3. Canadian air and precipitation sampling stations

3. Mexican Air Monitoring Program October 1967

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Déserticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6-by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month were needed to get a reliable average radioactivity at each station (*7*).

The maximum, minimum, and average beta-particle concentrations in surface air during October 1967 are presented in table 3.

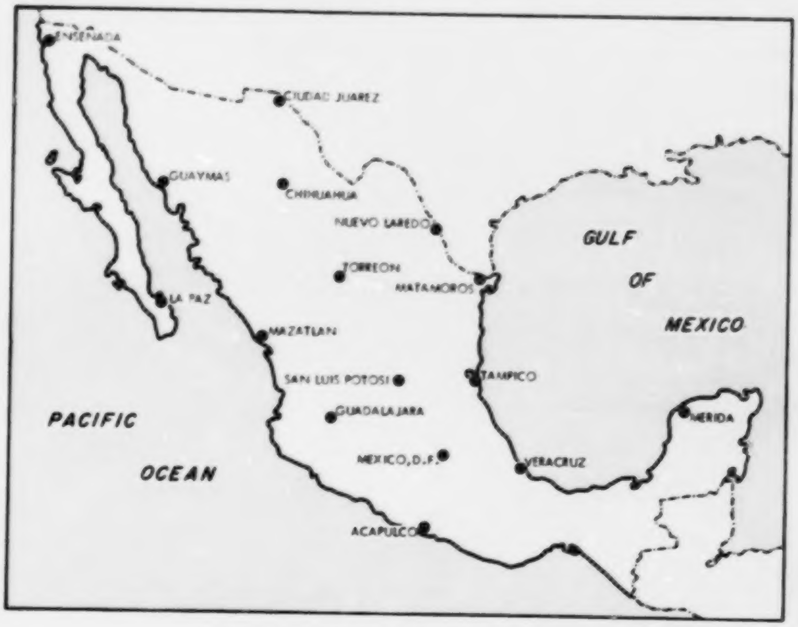

Figure 4. Mexican air sampling stations

Table 3. Mexican gross beta radioactivity of airborne particulates, October 1967

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	10	0.3	0.1	0.1
Chihuahua	1			
Ciudad Juárez	15	.7	.1	.1
Ensenada	12	.1	.1	.1
Guadalajara	NS			
Guaymas	NS			
La Paz	12	.1	.1	.1
Matamoros	NS			
Mazatlán	7	.1	.1	.1
Mérida	3	.1	.1	.1
México, D. F.	17	.1	.1	.1
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	12	.2	.1	.1
Torreón	15	.1	.1	.1
Veracruz	3	.1	.1	.1

NS, indicates no sample collected, station temporarily shut down.

4. Pan American Air Sampling Program October 1967

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the National Center for Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network before July 31, 1967. The air sampling locations are shown in figure 5.

The October 1967 air monitoring results are given in table 4.

Table 4. Gross beta radioactivity in surface air, PAHO October 1967

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	11	0.14	0.01	0.06
Bolivia: La Paz	19	.10	.01	.04
Chili: Santiago	29	.13	.02	.06
Colombia: Bogota	17	.02	.00	.01
Ecuador: Guayaquil	27	.16	.00	.07
Jamaica: Kingston	20	.05	.01	.02
Peru: Lima	19	.27	.00	.13
Venezuela: Caracas	19	.06	.01	.02
West Indies: Trinidad	19	.07	.00	.02
Pan American summary	180	0.27	0.00	0.04

[a] The monthly average is calculated by weighting the specific activity of the individual air samples with the length of sampling period.

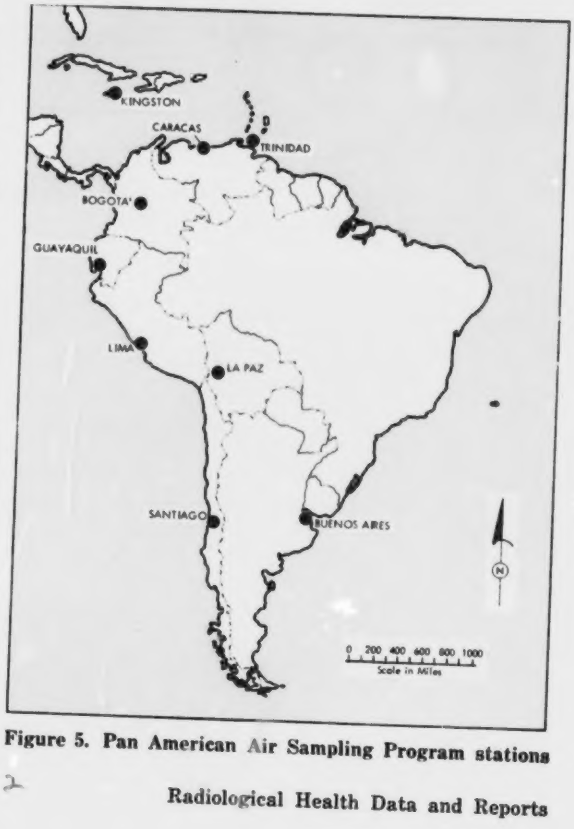

Figure 5. Pan American Air Sampling Program stations

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(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

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(5) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Iodine–131 in Bovine Thyroids, April–September 1967

National Center for Radiological Health
Public Health Service

The National Center for Radiological Health established a bovine thyroid network in October 1964 (*1*). Specimens are collected by the Livestock Slaughter Inspection Division, U.S. Department of Agriculture, and analyzed by gamma-ray spectroscopy for iodine–131 content at the Northeastern Radiological Health Laboratory, Winchester, Mass.

The network consists of collection areas (counties shaded in figure 1) located so as to cover, as nearly as possible, areas near major nuclear reactors, spent-fuel reprocessing plants and nuclear test sites. Details of sampling and analyses have been published earlier (*1*).

The results for April through September 1967 appear in table 1 and are listed chronologically within each state. The iodine–131 levels in thyroids analyzed were generally nondetectable although a small generalized rise to maximum levels of 20 to 25 pCi/g thyroid occurred in mid to late July.

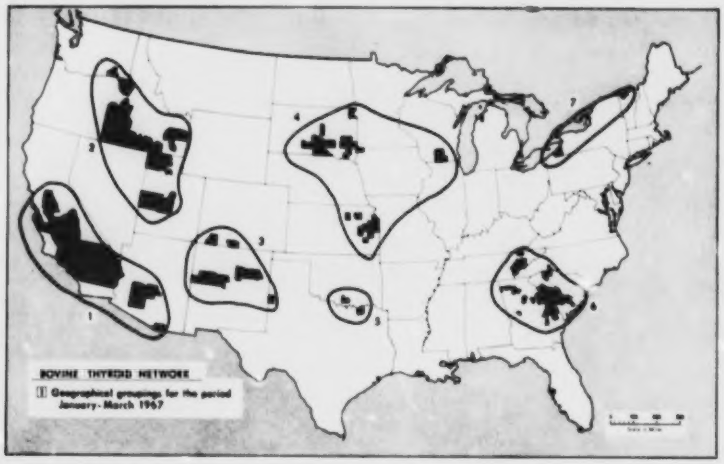

Figure 1. Counties sampled in bovine thyroid network April–September 1967

Table 1. Iodine-131 in bovine thyroids, April–September 1967

State	Date(s) of slaughter	County	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
Arizona	[a] 4/3–9/29	Graham (2) [c] Maricopa (38) Yavapai (1) Yuma (2)	43	[b] ND		
California	4/3	Merced	2	10	ND	19
	[a] 4/3–9/29	Calaveras (2) [c] Fresno (7) Kern (1) Kings (1) Los Angeles (7) Madera (5) Merced (27) Monterey (12) Orange (7) Riverside (3) Sacramento (4) San Benito (1) San Bernardino (42) San Joaquin (26) San L. Obispo (6) Santa Barbara (5) Santa Clara (3) Santa Cruz (4) Shasta (2) Stanislaus (22) Tulare (1)	188	[b] ND		
Georgia	[a] 4/4–7/5	Bartow (2) Bibb (1) Burke (6) Chatham (1) Clarke (10) Cobb (1) Columbia (9) Emanuel (2) Greene (3) Jefferson (4) Jenkins (2) Jones (2) Laurens (1) Lincoln (2) Lowndes (1) Screven (2) Toombs (8) Upson (5) Warren (5) Wilkes (3)	70	[b] ND		
	7/11	Newton	3	6	3	9
	[a] 7/17–9/26	Bartow (3) Burke (2) Candler (1) Cherokee (1) Clarke (5) Tobb (1) Columbia (1) De Kalb (3) Greene (5) Hancock (1) Laurens (6) McDuffie (4) Newton (3) Screven (6) Toombs (3) Upson (1) Walton (2) Warren (3) Wilkes (3)	54	[b] ND		
Idaho	[a] 4/15–7/7	Ada (18) Bonneville (5) Canyon (34) Cassia (7) Gem (5) Jerome (1) Minidoka (1) Owyhee (4) Washington (2)	77	[b] ND		
	7/14	Ada	5	18	9	22
	7/21	Canyon	2	9	8	9
	[a] 7/25–9/29	Ada (1) Adams (10) Canyon (15) Elmore (2) Gem (1) Payette (2) Valley (5) Washington (1)	37	[b] ND		
Iowa	[a] 4/3–9/28	Lyon (12) Sioux (5)	17	[b] ND		
Kansas	[a] 4/3–9/28	Douglas (7) Franklin (1) Johnson (1) Leavinworth (1) Linn (1) Lyon (4) Morris (2) Shawnee (1) Wabaunsee (1)	19	[b] ND		
Louisiana	4/13	Natchitoches	1	ND		
	6/21	Natchitoches	1	ND		
	7/14	Red River	1	9		
	[a] 7/25–9/28	Bossier (1) De Soto (1) Claiborne (1) Natchitoches (3)	6	[b] ND		
North Carolina	[a] 4/4–9/26	Cabarrus (8) Cleveland (8) Gaston (7) Mecklenburg (3)	26	[b] ND		
New York	[a] 4/5–9/27	Chautauqua	180	ND		
Oklahoma	[a] 4/3–7/12	Bryan (2) Carter (4) Choctaw (1) McCurtain (2) Pontotoc (2)	11	[b] ND		
	8/8	Carter	2	5	4	6
	[a] 8/17–9/28	Bryan (2) Carter (2) McCurtain (2) Pushmataha (1)	7	[b] ND		
Oregon	[a] 4/15–7/7	Malheur (1) Umatilla (11)	12	[b] ND		
	8/7	Harney	8	2	ND	7
	[a] 8/15–9/29	Crook (4) Harney (9) Malheur (5) Wallowa (2)	20	[b] ND		
South Carolina	[a] 4/4–7/19	Abbeville (2) [c] Aiken (3) Bamberg (5) Barnwell (7) Cherokee (2) Colleton (3) Greenwood (12) Laurens (1) Lexington (2) McCormick (2) Orangeberg (1) Richland (3) Saluda (14) Spartanburg (7) Union (1)	65	[b] ND		

See footnotes at end of table.

Table 1. Iodine-131 in bovine thyroids, April-September 1967—Continued

State	Date(s) of slaughter	County	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
South Carolina—Continued	7/25	Bamberg	1	8		
	[a] 7/25-9/26	Aiken (3) Bamburg (3) Barnwell (3) Cherokee (4) Colleton (2) Greenwood (9) Lexington (5) Richland (7) Spartanburg (3)	39	[b] ND		
South Dakota	[a] 4/3-6/30	Aurora (9) Brookings (6) Brown (1) Clark (4) Gregory (1) Hamlin (6) Hanson (1) Hutchinson (7) Lincoln (6) Lyman (4) McCook (8) Minnehaha (13) Roberts (1) Tripp (3) Turner (3) Yankton (1)	74	[b] ND		
	4/17	Minnehaha	2	5	ND	9
	7/11	Charles Mix	5	2	ND	8
	7/17	Faulk	4	8	6	10
	[a] 8/3-9/28	Charles Mix (3) Clark (1) Davison (10) Grant (1) Hanson (1) Hutchinson (2) McCook (4) Miner (8) Minnehaha (3) Roberts (4) Yankton (2)	39	[b] ND		
Tennessee	[a] 4/4-6/28	Blount(17) Cumberland(2) Grainger (2) Green (1) Hamblen (2) Jefferson (1) Knox (18) Loudon (3) Morgan (1) Roane (1) Sevier (15)	63	[b] ND		
	7/5	Blount	2	6	5	6
		Lexington	1	ND		
		Loudon	2	8	7	9
	7/5	Seveir	1	3		
	7/12	Knox	2	11	8	13
		Roane	4	11	8	16
	7/19	Blount	2	10	6	13
		Jefferson	1	7		
		Knox	2	15	6	24
		Sevier	1	4		
	7/26	Blount	2	2	2	2
		Knox	2	4	3	5
		Sevier	2	6	6	6
	8/2	Blount	1	6		
		Fentress	1	ND		
		Knox	4	4	3	5
	8/11	Blount	2	2	ND	4
		Seveir	3	2	ND	5
		Union	1	6		
	8/16	Blount	2	4	4	4
		Jefferson	1	8		
		Roane	2	15	5	24
		Sevier	1	3		
	[a] 8/22-9/26	Blount (13) Fentress (1) Hawkins (1) Jefferson (2) Knox (8) Loudon (1) Roane (1) Sevier (2)	29	[b] ND		
Texas	[a] 4/3-9/28	Cass (1) Collin (2) Denton (10) Fannin (2) Hunt (2) Kaufman (1) Rains (4)	22	[b] ND		
Utah	[a] 4/15-7/27	Davis (10) Sanpete (5) Weber (6)	21	[b] ND		
Washington	[a] 4/15-9/29	Asotin (2) Walla Walla (52)	53	[b] ND		
Wisconsin	[a] 4/3-9/28	Dane (22) Green (9) Rock (49)	80	[b] ND		

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[a] Samples were not collected on all dates during this period, but the interval includes several sampling dates.

[b] The results for this period were, for the most part, not detectable. Some randomly scattered positive results were obtained; but these represented barely detectable amounts of iodine-131 in the bovine thyroid (2 to 5 pCi/g).

[c] Numbers in parentheses represent the number of samples collected from that county during the interval indicated. These may have been collected over several dates during the period or on only one date.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1966	January 1967
July–December 1966	April 1967
January–March 1967	August 1967

REFERENCE

(*1*) BARATTA, E. J., E. R. WILLIAMS, and G. MURRAY. Iodine-131 in bovine thyroids, October–December 1964. Radiol Health Data 6:569-571 (October 1965).

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of the environmental radioactivity data follow for the Hanford Atomic Products Operation, Pinellas Peninsula Plant, and the Savannah River Plant.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Hanford Atomic Products Operation Calendar Year 1966[2]

Battelle Memorial Institute
Richland, Washington

Surveillance of the Hanford environs during 1966 showed that both the concentrations of radioactive materials in the vicinity and the environmental radiation doses were well within appropriate limits.

Results obtained from the Hanford environmental surveillance program for 1966 indicated that most of the environmental radiation dose for the majority of persons living in the Hanford environs was due to natural sources and world-wide fallout rather than to Hanford operations. The major source of low-level wastes released to the environment from Hanford plants was reactor cooling water, which was discharged to the Columbia River.

Two events occurred during 1966 which significantly influenced radiation levels in the Hanford environs. The first of these was an abnormal release of radioiodines from a production reactor to the Columbia River on February 11, 1966. The net effect of this release was to increase the thyroid dose to the typical Richland child from 6 percent of the limit (1965) to 9 percent of the limit (1966).

The second event resulted in a significant reduction of radiation levels in the Hanford environs during a 2-month period. A strike was called against Hanford contractors on July 8, 1966. Within a few days, all reactors were shut down and remained out of operation until late August. The overall effect of the extended reactor shutdown was to reduce the estimated annual doses to the GI tract, whole body, and bone, by as much as 2 percent of the appropriate limits from the 1965 values.

The highly unlikely but plausible combination of living habits that would result in an individual's receiving the largest radiation dose from Hanford-effluent radionuclides is postulated as:

1. Consumption of 200 meals per year of fish caught down river from the reactors,
2. spending 500 hours per year on the riverbank to catch the above quantity of fish,
3. consumption of meat, milk, fruit, and vegetables from irrigated farms in the Riverview district, and
4. consumption of drinking water from the Pasco system.

A person with such habits is called the

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[2] Summarized from Pacific Northwest Laboratory, Evaluation of Radiological Conditions in the Vicinity of Hanford for 1966, BNWL-439 (June 1967).

"maximum individual." During 1966, the "maximum individual" could have conceivably ingested enough radioactive materials of Hanford origin (mostly phosphorus-32) to provide an intake of 10 percent of the MPRI (Maximum Permissible Rate of Intake) specified by the AEC-ICRP (International Commission on Radiological Protection) for individuals in the general population (with bone as the critical organ). This same intake would have resulted in annual doses for 1966 that were 5 and 7 percent of the appropriate AEC-FRC (Federal Radiation Council) guidance for the GI tract and whole body, respectively.

The typical Richland resident received most of his radiation dose from natural background and world-wide fallout. The radiation dose from Hanford sources received by this population group originates, for the most part, from drinking water obtained from the Columbia River. Normally, the radiation dose received by the GI tract is the largest percentage of appropriate limits for the mixture of radionuclides present in drinking water. During 1966, however, the unusual release of radioiodines mentioned earlier resulted in an estimated maximum thyroid dose of 40 mrem. The dose to the 2 g thyroid of a typical Richland child as a result of the radioiodine release was 20 mrem. Including the latter increment, the thyroid dose to a typical Richland child for 1966 was only 9 percent of the limit.

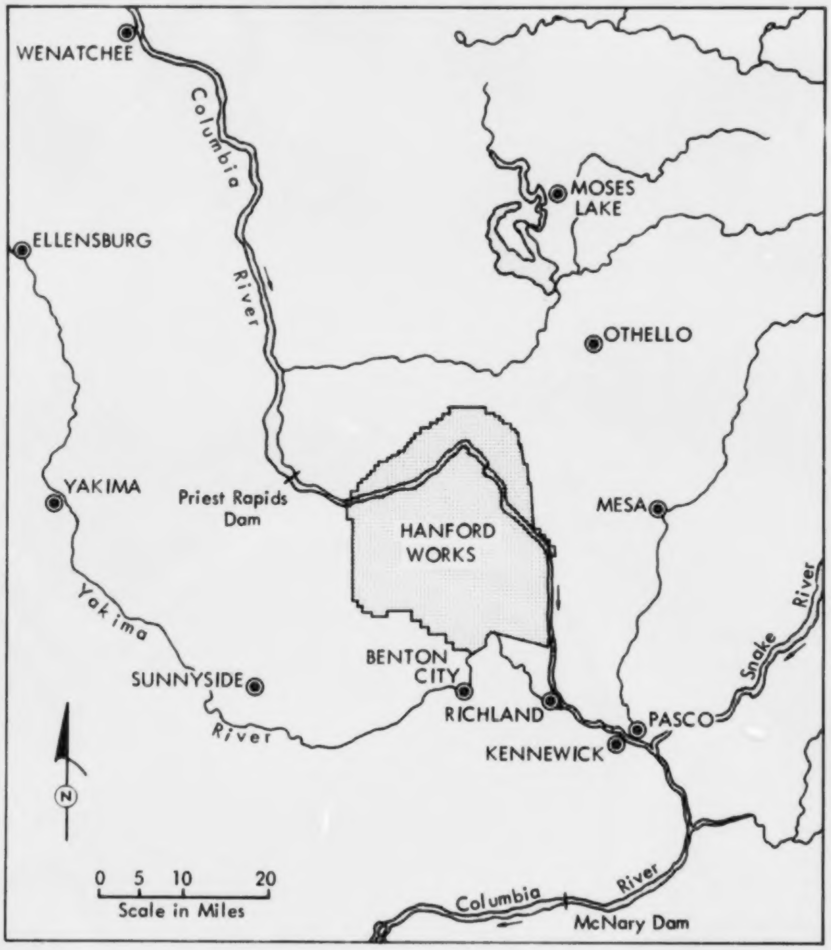

Figure 1. Hanford project environs

Except for the unusual release of radioiodines to the river during February, iodine–131 concentrations in the Hanford environs were at very low levels during 1966. Brief increases in iodine–131 concentrations in the environment occurred following the foreign nuclear weapons test of May 9 and October 27, 1966, but concentrations soon returned to the low levels experienced during most of 1966.

The Hanford plant[3] is located in a semiarid region of southeastern Washington State, where the average annual rainfall is about 16 cm (6 in.). This section of the State has a sparse covering of natural vegetation primarily suited for grazing, although large areas near the project have gradually been put under irrigation during the past few years. The plant site (figure 1) covers an area of about 1,300 km^2 (500 square miles). The Columbia River flows through the northern edge of the project and forms part of the eastern boundary. Near the plant production sites, the prevailing winds are from the northwest with strong drainage and cross winds causing distorted flow patterns. The meteorology of the region is typical of desert areas with frequent strong inversions occurring at night and breaking during the day to provide unstable and turbulent conditions.

The populated areas of primary interest are the tri-cities (Richland, Pasco, and Kennewick) situated on the Columbia River directly downstream from the plant. Smaller communities in the vicinity are Benton City, West Richland, Mesa, and Othello; and these together with the surrounding agricultural area, bring the total population near the plant to about 80,000 people.

During the course of operation, various radioactive wastes are generated by the several plant facilities. High-level wastes are concentrated and retained in storage within the project boundaries. Controlled releases of low-level wastes, for which concentration and storage is not feasible, are made to the ground. Practices governing radioactive waste disposal at the Hanford Plant are described in the Hearings on Industrial Radioactive Waste Disposal held by the Joint Committee on Atomic Energy, U.S. Congress in 1959 (*1*).

It is the purpose of this report to present an evaluation of the combined off-project effects of the radioactive-waste-disposal practices of all Hanford contractors. Radiation protection practices, including the effects of radioactive waste disposal, are governed by AEC Manual Chapters 0524 and RL 0524 (*2*). The section to which this evaluation is addressed stipulates that radioactivity in effluents released to uncontrolled areas shall not result in a radiation dose to individuals exceeding 0.5 rem/yr to the whole body or gonads or 1.5 rem/yr to the thyroid or GI tract.

The significance of bone seekers such as phosphorus–32 and strontium–90 requires special consideration and treatment because the rate of intake of phosphorus–32 has not been specifically studied by the Federal Radiation Council (FRC) (*3*) in relation to a dose-equivalent for the bone or bone marrow.

Where the FRC does not provide direct guidance, they suggest that ICRP-NCRP (National Council on Radiation Protection and Measurement) dosimetry methods be used (*4,5*). The ICRP values are used as a reference base, because the ICRP-NCRP recommendations imply a more conservative rate of intake for phosphorus–32. Rather than introduce additional confusion associated with dose-equivalents for bone derived by different techniques, the data for bone seekers have been expressed in terms of a maximum permissible rate of intake (MPRI).

The MPRI is taken as the maximum permissible concentration (MPC) in water for a given radionuclide, as recommended by the ICRP for persons in the neighborhood of controlled areas, multiplied by the rate of water intake as defined for the standard man. This amounts to one-tenth of the MPC for continuous occupational exposure multiplied by intake rates of 2.2 liters/day or 800 liters/yr (for annual estimates). In the case of phosphorus–32 the MPRI is 16 μCi/yr.

The radiological units used throughout most of this report are mrems (dose-equivalent). For the nuclides of interest at Hanford, and the organs for which radiation doses (in mrads) and dose-equivalents (mrems) are calculated, the number of rads equal the number of rems.

Included in this report are two types of measurements which are not necesarily relevant to dose evaluations. These are the concentrations of radionuclides in the Columbia River and concentration of iodine–131 in cattle thyroids which serve as trend indicators and as support for data used in dose calculations.

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[3] Operated during 1966 for the Atomic Energy Commission by the Batelle-Memorial Institute, Douglas-United Nuclear, Inc., the General Electric Company, Isochem, Inc., and ITT/Federal Support-Services, Inc.

All of Hanford's production reactors use Columbia River water for cooling. The N-reactor uses recirculating demineralized water as a primary coolant. All waste water containing significant amounts of radioactive materials is filtered through the ground before it reaches the river. The amount of radioactive material reaching the river from N-reactor is a negligibly small fraction of that released from the older reactors.

At the older reactors, some elements present in the cooling water are transformed into radionuclides during the single pass through the reactors. In addition, radioactive materials formed on the surfaces of fuel elements and process tubes are eventually carried away by the cooling water to the river.

Many of the radionuclides formed in reactor cooling water are short-lived and decay rapidly after formation. In addition to radioactive decay, some fraction of most radionuclides is removed from the river water by sedimentation and by uptake by aquatic organisms. Also present in the river are radionuclides contributed by fallout from nuclear weapons testing.

Samples of river water were collected above the production areas at Priest Rapids Dam and below the areas at the Richland water plant intake, McNary Dam and Bonneville Dam. Where possible, cumulative sampling equipment was installed and provided a more representative sample than the periodic grab samples obtained in the past. This cumulative sampling technique, however, makes it impractical to calculate the amounts of very short-lived nuclides; these must still be measured from grab samples. Within a few days after the July–August reactor shut down began, concentrations of reactor-effluent radionuclides in the Columbia River dropped to very low levels (in most cases, below the analytical limit). However, concentrations of zinc–65 did not drop as much as would be expected from known releases of this radionuclide to the river. It was evident that a significant amount of zinc–65 was retained in the river bed and was recycled to the water through continued scouring and leaching of the sediments.

The annual average concentrations of radionuclides measured routinely at Richland and Bonneville Dam are shown in table 1.

Table 1. Annual average radioactivity in Columbia River water, 1966

Radioactivity	Activity concentration (pCi/liter)	
	Richland	Bonneville Dam
RE+Y[a]	270	([b])
Sodium-24	2,600	([b])
Phosphorus-32	140	23
Chromium-51	3,600	1,300
Copper-64	1,400	([b])
Zinc-65	200	43
Arsenic-76	420	([b])
Strontium-90	1	([b])
Iodine-131	18	3
Neptunium-239	770	([b])

[a] Rare earths plus yttrium.
[b] Insufficient sampling data to provide a meaningful annual average.

Measurements on traverses across the river at Richland indicate a slightly nonuniform distribution of the longer-lived radioisotopes at this cross-section. Entries of the Yakima River some 16 km (10 miles) above Pasco and of the Snake River some 48 km (30 miles) above McNary Dam slightly influence the distribution of radionuclides below these two points. The magnitude of the influence varies with seasonal changes in the flow rate of the tributaries. Bonneville Dam is approximately 490 km (240 miles) below the Hanford reactors and represents the farthest downstream location where river water is routinely sampled for Hanford's environmental surveillance program.

The seasonal variation in flow rate of the Columbia River markedly affects the quantity of water available for dilution of reactor effluent released to the river. Also affected by the flow rate is the time required for a specific volume of water to move from one location to another. The annual average transport rate of selected radionuclides past the Bonneville Dam is given in table 2.

An estimate of the inventory of these radionuclides which exist in the ocean may be calculated by assuming an equilibrium between the rate of addition through the river and the rate of decay in the ocean. A constant rate of entry into the ocean equivalent to that indicated by the 1966 Bonneville Dam measurements would imply an inventory of about 190 curies of phosphorus–32, 17,000 curies of chronium–51, and 7,400 curies of zinc–65.

Table 2. Annual average transport rate past Bonneville Dam of selected radionuclides, 1963–1966

Radionuclide	Transport rate (Ci/day)			
	1963 [a]	1964	1965	1966
Phosphorus-32	12	12	11	9
Chromium-51	860	860	800	430
Zinc-65	28	44	49	21

[a] Rate of transport at Vancouver, Wash.

Radionuclides in drinking water

The city of Richland is the first community downstream from the Hanford reactors that uses the Columbia River as a source of drinking water supply. Pasco and Kennewick, a few miles farther downstream, also use the Columbia River as a source of drinking water. Continuous potable water samples were collected at the Richland water plant, and periodic samples were collected at Pasco and Kennewick. All of these samples were analyzed for the important individual radionuclides. The results of analyses of drinking water from these three cities are summarized in table 3.

The concentrations of short-lived radionuclides in the water at the time it is consumed are less than the values shown in table 3 because there is a significant transport time between the water plant and most consumers. The transport time may vary from hours to days depending upon the location of the customers on the distribution system and the water demand.

The calculated annual average dose to whole body, the GI tract and thyroid, and the percent MPRI for bone from sustained consumption of drinking water throughout the year at the three cities are presented in table 4.

The GI tract dose of Richland and Pasco residents was significantly lower in 1966 (about 10 percent and 30 percent, respectively) than in 1965 (*6,7*).

This is primarily attributed to the retirement of the three Hanford reactors and the extended shut down of all reactors during the summer of 1966.

The thyroid dose, however, was somewhat higher during 1966 than during 1965 (*10*), because of the unusual release of radioiodines to the river on February 11, 1966. The estimated thyroid dose (as a direct result of the release) received by a typical Richland child (2 g thyroid) drinking 0.4 liter of water per day was 20 mrem. The annual thyroid dose (including the above) to the same child from drinking water for 1966 was estimated to be 35 mrem. The maximum dose to a 2 g thyroid was estimated from a water intake rate of 0.8 liter per day. Such an intake rate would have resulted in thyroid doses from drinking water of 40 mrem during February 1966, and 70 mrem for the entire year. Corresponding thyroid doses for 1965 were 20 mrem for the typical Richland child and 40 mrem for the maximum child.

Table 3. Annual average concentration of radioactivity measured in drinking water, 1966

Radioactivity	Radioactivity concentration (pCi/liter)		
	Richland	Pasco	Kennewick
Total beta	5.6	1.7	0.32
RE+Y [a]	77	28	(b)
Sodium-24	1,700	540	64
Phosphorus-32	92	36	11
Chromium-51	4,200	3,100	1,300
Copper-64	430	68	39
Zinc-65	68	70	<20
Arsenic-76	200	46	12
Strontium-90	<1	<1	(b)
Iodine-131	14	9	12
Neptunium-239	560	370	57

[a] Rare earths plus yttrium.
[b] Insufficient data to provide a meaningful annual average.

Table 4. Calculated annual dose for selected organs from routine ingestion of drinking water, 1966[a]

Location	Whole body (mrem)	GI tract (mrem)	Bone (percent of MPRI)	Thyroid (small child 0.4 liter/day) (mrem)
Richland	1.9	31	0.8	35
Pasco	<1	9	0.1	22
Kennewick	<1	1	<0.1	30

[a] Here and elsewhere in this report where a dose (mrem) from an ingested nuclide is expressed, the determination is made from parameters used by the ICRP to translate dose rates into maximum permissible concentrations for drinking water. In most cases, the estimated annual intakes of individual radionuclides were multiplied by conversion factors derived from the ICRP parameters and published by Vennart and Minske (*9*).

Note: The "standard man" average intake rate of 1.2 liter/day was used in this calculation (*4*).

Radionuclides in fish and waterfowl

The Columbia River is popular for sports fishing above and below the Hanford plant, and the fish that feed downstream from the reactors acquire some radionuclides from the reactor effluent. Whitefish are the sports fish that usually contain the greatest concentration of radioactive materials. Further, they can be caught during winter months when other sports fish are difficult to sample. For these reasons, whitefish are sampled most intensively to follow trends.

Concentrations of phosphorus-32 in whitefish during 1966 tended to follow seasonal trends observed in past years; however, phosphorus-32 concentrations in the fall months were at much lower levels than in previous years (*6,7*), primarily as a result of the extended reactor shut down during the summer. Concentrations of zinc-65 in whitefish were affected little by the extended reactor shut down, probably owing to recycling of this radionuclide from the river bottom during the shut down period. The average concentrations of phosphorus-32 and zinc-65 in whitefish sampled down stream from the reactors during 1966 were 110 pCi/g and 23 pCi/g, as compared with 200 pCi/g phosphorus-32 and 27 pCi/g zinc-65 during 1965.

The quantities and kinds of fish caught by local fishermen have been estimated previously from surveys carried out by personnel of the State of Washington, Department of Game. Additional dietary data collected during 1966 did not change these estimates. Those individuals who probably ingest the largest amounts of phosphorus-32 are fishermen who claim to eat bass, crappie, and perch, as often as three to five times a week. This large number of fish meals indicates an annual intake of about 40 kg (about 90 pounds) of fish. On the basis of the 40 kg of fish consumption claimed by the "maximum individual" (200 fish meals/year), the intake of phosphorus-32 during 1966 could have been approximately 1.0 μCi, or approximately 6.2 percent of the MPRI for bone as the critical organ.

Many persons have been counted in the Hanford whole-body counter, including some avid fishermen. Amounts of zinc-65 detected in these people were much less than expected on the basis of their stated consumption of fish. These results supported the findings of the past years which suggested that fishermen tend to overestimate their fish consumption. Therefore, the actual ingestion rates of both phosphorus-32 and zinc-65 are undoubtedly substantially lower than currently postulated from the fishermen's estimates.

Migratory waterfowl, such as ducks and geese, which have utilized the Hanford section of the Columbia River and the swamps and ponds within the project boundaries may contain phosphorus-32, zinc-65, and small amounts of other radionuclides. Some of these waterfowl remain in this general area throughout the year. One hundred twenty-four of the water fowl samples collected during 1966 had concentrations of phosphorus-32 less than 50 pCi/g of flesh (wet weight), 51 samples were above 50 pCi/g but less than 500 pCi/g, and the remaining 10 samples were over 500 pCi/g. The maximum concentration of phosphorus-32 was 2,900 pCi/g. However, as a potential source of this radionuclide to people, the waterfowl are of much less significance than the fish because they cannot be harvested in such large numbers by individuals and because of "dilution" by large flights of migrating birds that move through the region at the time of the year when hunting is allowed.

Radionuclides in marine organisms

Zinc-65 and phosphorus-32 are the only radionuclides in the reactor effluent that are found in sufficient abundance beyond the mouth of the Columbia River to be of radiological interest. Oysters have been found to contain higher concentrations of zinc-65 than other common seafood organisms. The extended reactor shut down during the summer of 1966 had very little effect on concentrations of phosphorus-32 and zinc-65 in oysters. In the case of phosphorus-32, a normal seasonal minimum occurs in the late summer; and in the case of zinc-65 recycling from the river bottom held zinc-65 concentrations near their normally expected levels.

Annual average concentrations of zinc-65 have decreased over the past 3 years while phosphorus-32 concentrations have remained at about the same level during that time (*6,7*). The average concentrations in samples taken throughout 1966 were 28 pCi/g, zinc-65 and 2.9 pCi/g, phosphorus-32.

Consumption of oysters containing these concentrations at the rate of 50 g/day[1] would result in an annual dose of about 6 mrem to the GI tract and 4 mrem to the whole body. These intakes represent 0.4 percent of the MPRI for bone as the critical organ.

Radionuclides in the atmosphere

At Hanford, gaseous waste from the chemical separations facilities is released to the atmosphere through 70 meters high (230 feet) stacks after most of the radioactive materials have been removed by filtration and scrubbing. These radioactive materials are primarily associated with process vessel off-gases. Ventilation air from laboratory and reactor building contains comparatively minor amounts of radioactive materials under normal operating conditions.

Measurements of airborne iodine-131 were made routinely at numerous locations within the Hanford reservation and around the plant perimeter. The results of iodine-131 measurements for the past few years are summarized in table 5.

Table 5. Annual average iodine-131 concentrations in the atmosphere, 1963-1966

Location	Distance from separation stacks (miles)	Iodine-131 (pCi/m³)			
		1963	1964	1965	1966
Prosser Barricade [a]	14	(b)	0.02	0.03	0.02
Benton City	20	0.03	.06	.03	.01
Richland	23	.02	.02	.02	.01
Pasco	32	.02	.01	.03	.01

[a] Installed during October 1963.
[b] Insufficient sampling data to provide a meaningful annual average.

The four locations listed in table 5 lie within a 45° sector southeast to south of the separations center. Such concentrations sustained in inspired air imply an annual dose to the thyroid of the "standard man" of less than 1 mrem.

Air filter sampling is maintained at several locations within the Hanford reservation and around the plant perimeter. Air filter results are not used in estimating exposure but serve to illustrate the trends in atmospheric contamination. Sudden changes in concentration are used to signal the need for shifted emphasis in other portions of the environmental monitoring program related to atmospheric contamination.

Radionuclides in milk and produce

The radioactivity found in locally grown agricultural produce can be influenced by deposition of airborne radionuclides or by irrigation with river water containing reactor effluent radionuclides. The chemical separations facilities are generally the principal local source of airborne radionuclides. The closest farming area to the separations facilities is about 21 km (13 miles) away.

Most irrigated farms near the Hanford plant use water drawn from the Yakima River, or from the Columbia River above the project. There are, however, two small areas which regularly take water from the Columbia River downstream from the reactors for irrigation. They are the Ringold farms and the Riverview district west of Pasco, located respectively 24 and 48 km downstream from the reactors.

The principal products from the larger farm plots are hay, fruit, beef, and dairy products. This area is centered 48 km (30 miles) southeast of the chemical separations plants. Another agricultural area near the project is Benton City, located on the Yakima River about 20 miles (32 km) directly south of the separations facilities.

A comprehensive milk surveillance program maintained during 1966 included samples from local farms and dairies and from commercial supplies available to people in the tri-cities. The concentrations of radionuclides found in milk sold by commercial outlets were similar to that reported by the U.S. Public Health Service and the Washington State Department of Health. Milk from local farms irrigated with water drawn from the river downstream from the reactors contained phosphorus-32 and zinc-65 as well as fission products of fallout origin.

Generally, the average concentration of iodine-131 in both local and commercial milk was at or below the analytical limit of 3 pCi/liter. Brief increases in iodine-131 concentrations were noted in June, following the foreign atmospheric nuclear weapons test on May 9; in July and October, following small, transient increases in the release rate of iodine-131 from a chemical separations facility; and in November, following the foreign atmospheric nuclear tests on October 27. The maximum concentration of iodine-131 observed in milk was 15 pCi/liter on June 2, 1966.

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[1] Expected to be used as a reference consumption rate in future national shellfish quality standards.

Dairy farms in the Ringold and Riverview area that utilize the Columbia River for irrigation of pasture land and hay fields produce milk containing both phosphorus-32 and zinc-65. The extended reactor shut down during July and August had very little effect on the concentrations of these two nuclides in milk because of other variables, such as irrigation and feeding practices. During 1966, the average concentration of phosphorus-32 in milk from Ringold and Riverview farms was 480 pCi/liter and the average concentration of zinc-65 was 370 pCi/liter. Commercial milk distributed in the tri-cities usually does not contain phosphorus-32 and zinc-65 because it is obtained principally from areas not irrigated with Columbia River water.

Adult residents consuming milk (1 liter/day) obtained from the Ringold-Riverview area would receive an annual dose from phosphorus-32 and zinc-65 amounting to about 5 mrem to the GI tract and 2 mrem to the whole body. The intake of phosphorus-32 and zinc-65 would be equal to about 1.2 percent of the MPRI for bone. The intake of iodine-131 would have resulted in a dose of about 2 mrem to the thyroid.

Miscellaneous fresh farm produce was sampled periodically for radioanalysis during the 1966 growing season from local farms and commercial outlets. Results of these measurements were similar to those of previous years (*6,7*) and indicated that only small quantities of radionuclides are present in locally grown produce.

The concentrations of iodine-131 found in samples of fresh vegetables collected from local farms and markets during the period of May through September 1966, were less than or approximately equal to the analytical limit of 0.05 pCi/g. There was no significant difference noted in concentrations found in local farm produce and in produce purchased from commercial outlets. If these fresh vegetables had been consumed at the rate of 100 g/day throughout the year, the average annual intake from this source would have been about 730 pCi for iodine-131. Such an intake would imply an annual dose of about 1 mrem to the thyroid of a typical adult Richland resident.

Concentrations of iodine-131 in cattle thyroids

Thyroids of cattle are collected periodically from slaughter houses in Moses Lake, Yakima, Walla Walla, Wenatchee, and Pasco, and are sent to Hanford for radioanalysis. The average concentrations measured in beef thyroids were generally at or below the analytical limit of 5 pCi/g for iodine-131 during most of 1966, except for a brief increase in June following the May 9, 1966, foreign atmospheric nuclear weapons test, and in November following the foreign atmospheric nuclear weapons tests in October. The maximum concentration of iodine-131 in bovine thyroids was 150 pCi/g from samples collected in November at Pasco and Walla Walla.

External radiation

Ionization chambers are stationed on the Hanford reservation and in Richland to estimate the gamma radiation exposure from external sources. Measurements in air 1 meter above ground during 1966 averaged about 0.36 mR/day or 130 mR/yr at Hanford and about 0.28 mR/day or 100 mR/yr at Richland, somewhat lower than measured during the past 3 years (*6,7*). Essentially all of this exposure is from natural background and worldwide fallout from nuclear testing.

Direct radiation measurements are also made in the Columbia River at several locations with pocket-type ionization chambers submerged 0.6 to 1.5 meters (2 to 5 feet) below the surface of the water. Exposure rates are higher in the river than overground because of the presence of gamma-ray emitters (especially sodium-24) in reactor effluent. In the vicinity of Richland, the average exposure rate in the water during the months of April through October was about 2 mR/day. A person swimming or boating in the river for a total of 240 hours during the year could have received a whole-body exposure of 20 mR.

An estimate of the external radiation exposure received by people that fish from the shore in the vicinity of the Hanford project is complicated by the daily fluctuation in the level of the river but the exposure rate at the river's edge during 1966 was lowest during the freshet in late June and highest during low river flow rates in the fall months. Recent measurements of the gamma-ray spectrum indicate that zinc-65 accumulated by algae growth on the subtrate at the river's edge is responsible for a major portion of a fisherman's radiation exposure. Assuming that an avid fisherman spent as many as 500 hours on the river bank in the vicinity of Richland during 1966, his external exposure could have been about 13 mR.

Radioactive wastes released to ground

Liquid wastes from the chemical separations areas are routed to various facilities dependent upon their burden of radionuclides. High-level wastes (normally containing concentrations greater than 100 μCi/ml) are stored in underground concrete tanks lined with steel. Intermediate level wastes (ordinarily containing concentrations in the range of 5 x 10^{-5} μCi/ml to 100 μCi/ml) are sent to underground "cribs" from which they percolate into the soil. The areas selected for intermediate waste disposal and high level waste storage have soil with good ion exchange capacity and ground water depths of 50 to 100 meters (165 to 330 feet). Low-level wastes (usually containing less than 10^{-5} μCi/ml) are sent to depressions in the ground where surface ponds or "swamps" have been formed as a result of the continuous addition of the relatively large volumes of water. Wells have been drilled in and around crib and tank storage areas to detect any leaks in the tanks and to measure radionuclides that have reached the ground water. Virtually all of the radionuclides present in the ground water have been introduced with liquids sent to the cribs. The bulk of this radioactive material is ruthenium-rhodium-106. A substantial amount of tritium has also been sent to the ground with the intermediate level liquid wastes from the separations plants.

In all probability, some tritium and ruthenium-rhodium-106 originating at the chemical processing areas is now entering the Columbia River. However, the contribution of these nuclides is too small to be detectable in the river water and any exposure from them is therefore negligible.

Fallout from nuclear weapons testing

In addition to the radiation dose received by residents of the Hanford environs from Hanford-originated radionuclides and from natural background radiation, a dose increment due to fallout nuclides is also received. Locally this increment is below the national average because of the low rainfall in this region (6.3 inches/year). Measurements of fallout, like measurements of natural background radiation, are necessary to place the radiation dose resulting from Hanford operations into proper perspective. The fallout nuclides of interest during 1966 were tritium, strontium-90, iodine-131, and cesium-137. Although a small transient increase in iodine-131 concentrations was observed in June and November (following the foreign atmospheric nuclear weapons tests) the resulting thyroid dose was negligible.

Tritium (another fallout radionuclide), although occasionally detectable in Columbia River water, was at such low levels (2 nCi/liter) that routine consumption of water obtained from the Columbia River implied an annual dose to the whole body of the "maximum" individual of less than 1 mrem.

Concentrations of strontium-90 measured in milk produced locally are similar to concentrations found in commercial milk produced in areas that are remote from the Hanford plant. Strontium-90 found in milk from local farms averaged about 5 pCi/liter. The concentration of cesium-137 in milk analyzed at Hanford was generally near the analytical limit of 30 pCi/liter. Worldwide fallout is the principal source of strontium-90 and cesium-137 in milk.

About 10 percent of the total intake of strontium-90 by local residents during 1966 came from drinking water obtained from the Columbia River. As in the case of milk, this strontium-90 was of fallout origin.

Based on the same dietary information used in other sections of this report, the total intake of strontium-90 during 1966 was about 0.006 μCi for the "maximum" individual and 0.005 μCi for the "typical" Richland resident. The total intake of cesium-137 during 1966 was about 0.02 μCi for both the "maximum" individual and the "typical" Richland resident. The estimated annual dose from fallout radionuclides present in the Hanford environs is given in table 6.

Table 6. Annual radiation dose from fallout radionuclides, 1966

Radionuclide	Organ	Radiation dose (mrem)	
		Maximum individual	Average Richland resident
Tritium	Whole body	<1	<1
Strontium-90	GI tract	<1	<1
	Whole body	5	5
	Bone	(2 percent MPRI)	(5 percent MPRI)
Cesium-137	GI tract	<1	<1
	Whole body	<1	<1
	Bone	(0.1 percent MPRI)	(0.1 percent MPRI)

For calculating a dose to the thyroid gland, the most appropriate sample of the exposed population would appear to be small children living in Richland who drank water from the municipal system (0.4 g/day), milk (0.6 liter/day) obtained from the local stores, and fresh vegetables (25 g/day) obtained from local markets. The total intake of iodine-131 during the year from these sources would be about 2,600 pCi, or an average of about 7 pCi/day. This intake is within FRC Range I and indicates a radiation dose of 44 mrem (9 percent of the limit) for 1966 (figure 3).

The estimated whole body dose (figure 3) of the average Richland resident from radionuclides of Hanford origin was 4 mrem. Whole body doses from natural background (excluded from the FRC Guide) and fallout sources in this region are estimated at about 100 mrem/year, and 5 mrem/year, respectively.

Table 7 provides a summary of radiation doses estimated for individuals and population groups residing in uncontrolled areas in the Hanford environs.

Table 7. Summary of radiation doses in uncontrolled areas of the Hanford environs, 1966[a]

Organ	"Maximum" individual			Average Richland resident		
	Annual dose (mrem)	Limit (mrem)	Percent of limit	Annual dose (mrem)	Limit (mrem)	Percent of limit
GI tract	70	1,500	5	33	500	7
Thyroid (infant)[b]	86	1,500	6	44	500	9
Whole body	33	500	7	4	170	2
Bone	([c])	([d])	([f])	([d])	([e])	[f]0.8

[a] Represents individuals or population groups residing in uncontrolled areas near the Hanford plant.

[b] As a result of the radioiodine release during February, the maximum thyroid dose during 1966 was not received by a Riverview (Pasco) infant as in past years. A Richland child with similar dietary habits received an annual thyroid dose of 86 mrem, while the Riverview child received a thyroid dose of 61 mrem for 1966.

[c] Not calculated.

[d] AEC-ICRP MPRI for "maximum" individual—16 μCi ^{32}P/yr and 800 μCi ^{65}Zn/yr.

[e] AEC-ICRP MPRI for "typical" Richland resident—5.3 μCi ^{32}P/yr and 270 μCi ^{65}Zn/yr.

[f] Value represents percent of maximum permissible rate of intake specified by the International Commission on Radiological Protection for individuals in the general population.

Radiation exposure summary

It is not possible to determine the precise radiation dose received by every individual because of variations in the kind and quantity of food consumed, variations in sources of food supply, and many variations in personal living habits. These inherent variations among individuals require a somewhat subjective approach when estimating the probable radiation exposure in relation to various established limits. The FRC has provided two sets of guides against which doses from environmental sources may be judged; that is, one for the individuals that receive the greatest dose, and the other for the average dose received by the general population (taken as one-third of that set for individuals). For the Hanford environs, doses from the various sources described in the preceding sections have been compiled in two ways to allow comparisons with guides for both the individual and the general population. In one case, a hypothetical but plausible individual has been assigned dietary and other habits that would result in what would seem to be the greatest rational dose. For the general population a dose has been estimated for what is called the "typical" Richland resident[5].

Some residents may receive a larger dose than calculated for the "typical" Richland resident but it is improbable that any would receive as much as that calculated for the "maximum" individual. Included in this intermediate group are families that subsist largely on foodstuffs produced on farms irrigated with water taken from the Columbia River downstream from the reactors.

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[5] The infeasibility of obtaining completely realistic dietary data for the typical resident leads to the assumptions which tend to slightly overestimate his dose. For example, it is assumed that no radioactive decay takes place during the transport of drinking water to the user and that no radioactivity is lost from food during preparation.

The "maximum" individual

Attempts have been continued to identify the individuals living in the Hanford environs that receive the greatest radiation dose. Experience accumulated from the environmental surveillance program indicates such individuals are undoubtedly persons that frequently eat fish caught locally in the Columbia River, and foodstuffs grown on farms irrigated with Columbia River water. Additional data collected during 1966 continued to support the assumption that fish, consisting mainly of crappie, perch, and bass, caught near Burbank (figure 2) are the most important source of radionuclides for the "maximum" individual. On the basis of an assumed consumption of 200 fish meals/year and radiochemical analyses of such fish, the intakes of phosphorus-32 and zinc-65 for the "maximum" individual during 1966 would have amounted to 1.0 and 0.5 μCi, respectively. Whether this amount of fish was actually eaten by the individual was not confirmed. However, other persons reporting an unusually high consumption of local fish were counted in the whole body counter and were found to have far less zinc-65 deposited than predicted on the basis of their estimates of the quantities of fish eaten. As a basis for calculating the intake of radionuclides from fish, we have continued to use the maximum reported consumption of 200 fish meals per year.

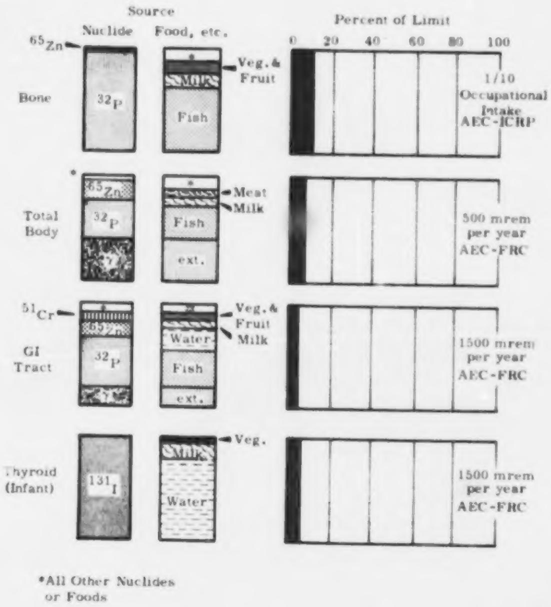

Figure 2. Estimated dose to "maximum" individual, 1966

The consumption rates of other foods for the hypothetical "maximum" individual are based on the maximum intakes described in various dietary surveys. It is assumed that each day this individual consumes 2 liters of water from the Pasco system, 1 liter of milk, 230 grams of beef, 20 grams of chicken, 80 grams of eggs, 200 grams of fresh leafy vegetables (in season), and 1,400 grams of all other vegetables and fruits, all produced on river irrigated farms in the Riverview District. The composite doses from these sources are illustrated in figure 2.

In past year, the maximum thyroid dose has been attributed to a child living in the Riverview farm district (Pasco). On the basis of a daily intake of 1 liter of farm milk, 50 grams of fresh-leafy farm vegetables, and 0.8 liter of water from the Pasco system, the thyroid dose received by a Riverview child during 1966 was 61 mrem (4 percent of the limit). However, a Richland child with similar dietary habits received a higher thyroid dose during 1966 than the Riverview child as a result of the radioiodine released during February. On the basis of a daily intake of 1 liter of commercial milk, 50 grams of fresh leafy commercial vegetables, and 0.8 liter of water from the Richland system, the thyroid dose received by the "maximum" child during 1966 was 86 mrem, or 6 percent of the FRC radiation protection guide for individuals.

The "typical" Richland resident

The vast majority of people who live in Richland obtain their food from local commercial stores (rather than directly from farms) and consume little or no fish caught from the Columbia River. The principal sources of radionuclides ingested by these people are from worldwide fallout and from drinking water obtained from the Columbia River.

The contribution from Hanford-created radionuclides in drinking water is substantially different for the three cities as discussed previously in the section on radionuclides in drinking water. The GI tract dose in Richland was greater than in the cities farther down river because the short-lived nuclides are in greater abundance. As shown in figure 3, the estimated dose to typical Richland residents for 1966 was about 33 mrem, or 7 percent of the maximum permissible dose. Ninety-three percent of the GI tract dose was contributed by drinking water.

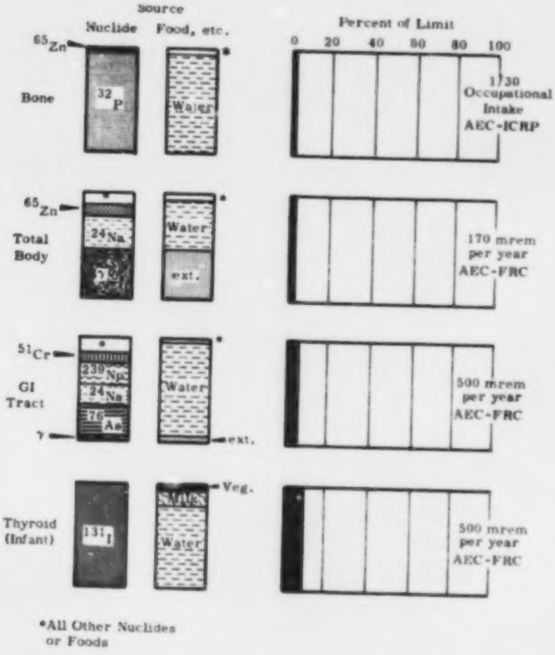

Figure 3. Estimated dose to "typical" Richland resident 1966

Conclusions

During 1966, the environmental surveillance program of the Hanford environs again showed that the amounts of radioactive materials present were well within nationally accepted limits at all times.

A release of radioiodines to the river from a production reactor on February 11, 1966, warranted special assessment of the radiation dose to persons in the Hanford environs. The effect of the release was to increase the thyroid dose received by the "typical" Richland child from 6 percent of the limit (1965) to 9 percent of the limit for 1966, and to have the maximum annual thyroid dose (86 mrem) occur in Richland rather than in the Riverview district.

The effect of the 2-month reactor shutdown period following the July 8 strike against Hanford contractors was to contribute to a reduction in the GI tract and whole body doses by about 1 percent of the applicable limits and then to help reduce the percent MPRI (bone) for the "maximum" individual from 12 percent (1965) to slightly less than 10 percent during 1966. The retirement of three Hanford reactors during 1964-1965 also contributed to the reduction in environmental radiation doses during 1966.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
Calendar year 1964	February 1966
Calendar year 1965	February 1967

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2. Pinellas Peninsula Plant
January–June 1967[1]

General Electric Company
St. Petersburg, Florida

Pinellas Peninsula Plant, shown in figure 4 is an electronic component production facility. The plant maintains an environmental monitoring program to measure the levels of radioactive environmental contamination associated with plant effluents. These measurements serve as an index of the effectiveness of the plant's contamination control measures. Effluent radioactivity concentrations and associated atmospheric and stream dilution factors indicate offsite radioactivity concentrations encountered by the general population are substantially lower than the guides for continuous nonoccupational exposure established by AEC and documented in the "AEC Manual."

Sewer effluent monitoring

A combined sewer effluent sample is obtained daily near the perimeter of the plant's property. During the sampling period 25 of 246 samples analyzed showed detectable concentrations of tritium (90 x 10^4 pCi/liter)[2]. The maximum concentration, 1.2 x 10^6 pCi/liter, which was detected on May 12, 1967, amounted to 39 percent of the continuous nonoccupational exposure guide. Calculations based on radioactivity releases from the process waste system, and the plant's water discharges, indicate that the average tritium concentration in the combined sewer effluent for the first half of 1967 was less than 7.3 percent of the AEC Radiation Protection Standard for continuous nonoccupational exposure.

Air monitoring

Air samples are obtained periodically in areas up to 2 miles downwind from the exhaust stack. Analysis of the one sample collected during the sampling period revealed no detectable amounts of tritium gas (9.6 x 10^6 pCi/m^3) or tritium oxide (5.0 x 10^3 pCi/m^3).

Surface water sampling

Surface water samples are collected at monthly intervals at selected locations within 8 miles of the plant. The sampling areas are determined by interrelating the concentrations of radioactivity in exhaust stack effluent with meteorological data. There were no indications of tritium oxide (9.0 x 10^4 pCi/liter) in the 39 surface water samples analyzed during the sampling period.

Milk sampling results

Eighteen samples of raw milk were collected from local dairy farms and analyzed by the Florida State Board of Health during the first half of 1967. No detectable concentrations (9.0 x 10^4 pCi/liter) of tritium were evident.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1966	February 1967
July–December 1966	July 1967

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[1] Summarized from "Environmental Monitoring, January 1 through June 30, 1967." General Electric Company, Pinellas Peninsula Plant, St. Petersburg, Fla.

[2] Expressions in parenthesis indicate limits of detectability in the respective environmental samples.

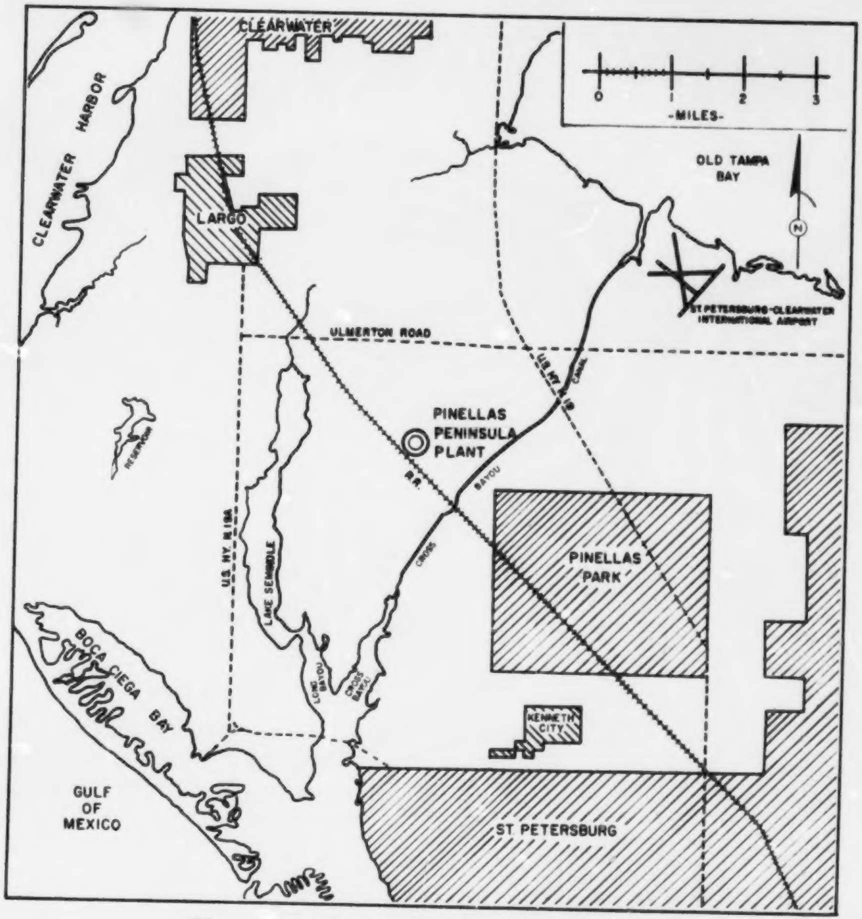

Figure 4. Location of Pinellas Peninsula Plant

3. Savannah River Plant January–June 1967[5]

E. I. du Pont de Nemours
Aiken, South Carolina

The Savannah River Plant (SRP), built and operated for the Atomic Energy Commission by E. I. du Pont de Nemours and Company, occupies an area of 312 square miles along the Savannah River, 22 miles downstream from Augusta, Ga. Production facilities include a fuel preparation area, four reactors, two fuel separation areas, and a heavy water production plant. A basic goal in plant operation is total containment of radioactive waste. Although some very low-level gaseous and liquid wastes are discharged to the environment in controlled releases, dispersal is adequate to ensure environmental concentrations below recommended guides.

The DuPont environmental monitoring group has maintained a continuous monitoring program since 1951 (before plant startup) to determine the concentrations of radioactive materials in a 1,200-square mile area outside the plant. Included in this area are parts of Aiken, Barnwell, and Allendale counties in South Carolina, and Richmond, Burke, and Screven counties in Georgia. This surveillance determines the magnitude and origin of any radioactivity above natural levels. Measured concentrations of radionuclides in air, water, and milk are compared with the maximum permissible concentrations (MPC) recommended by the International Commission on Radiological Protection (ICRP), or the daily intake guides recommended by the Federal Radiation Council (FRC).

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[5] Summarized from "Effect of the Savannah River Plant on Environmental Radioactivity, Semiannual Report, January–June 1967," (DPST-67-30-2).

Sensitive instruments, which can detect traces of radioactive materials far below concentrations of hazard significance, are used to determine radioactivity in the environs. Plant-released radioactivity cannot be readily distinguished from weapons tests fallout, and both are included in the reported concentrations. Maximum and minimum values given are for individual samples collected during the report period.

Atmospheric monitoring

Concentrations of radioactive materials in the atmosphere were measured by biweekly analyses of air filters collected at five monitoring stations near the plant perimeter and 10 stations around a circle of about 25-mile radius from the center of the plant (figure 5). Deposition rates of radioactive material at each station were also determined by monthly analyses of rainwater ion exchange columns (fallout collectors). The monitoring stations are spaced so that a significant release of airborne radioactivity by SRP would be detected regardless of the prevailing wind. All stations operate continuously. Four additional air monitoring stations at Savannah and Macon, Ga., and at Columbia and Greenville, S. C., are so distant from SRP that the effect of SRP operations is negligible; they are reference points for determining background radioactivity levels (figure 6). This system permits comprehensive surveillance of atmospheric radioactivity and also makes it possible to differentiate between weapons test fallout and SRP releases.

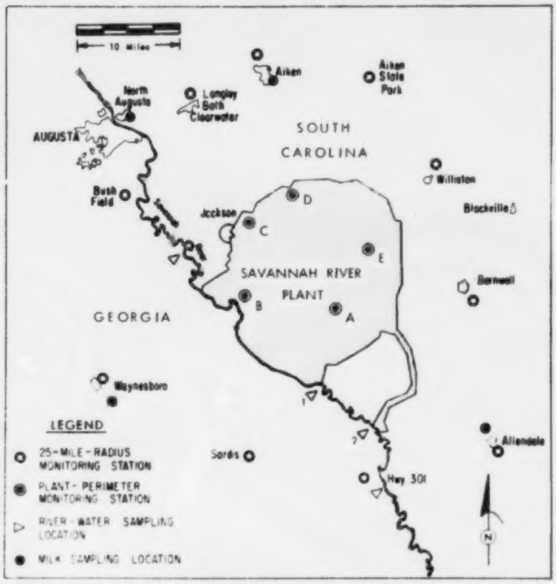

Figure 5. Environmental sampling locations, Savannah River Plant

The small amount of filterable beta radioactivity released to the atmosphere, primarily from the fuel separations areas, was obscured by fallout from nuclear weapons tests. The influence of the weapons tests which resumed in September 1961 is shown in figure 7. The rises in early 1964, 1965, and 1966 were the result of the anticipated spring increases in the mixing of stratospheric debris into the troposphere. The concentrations of radionuclides in air during June 1967, as in October 1966 were the lowest ever measured in this area.

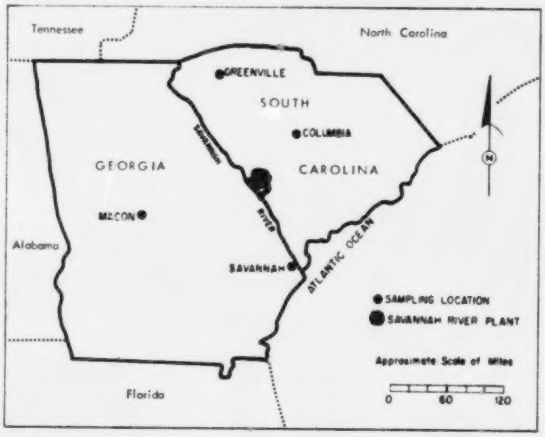

Figure 6. Distant air monitoring stations, Savannah River Plant

Radioactivity in air, determined from filter analyses, is shown in table 9. The January–June 1967 concentrations of filterable beta radioactivity (0.15 pCi/m^3) and alpha radioactivity (0.0007 pCi/m^3) in air were 0.2 and 1.8 percent of the respective MPC's. Tritium oxide concentrations in air, at the plant perimeter and at the 25-mile stations, did not exceed 1.1 percent of the MPC. Iodine–131 concentrations in routine air samples were less than 0.02 pCi/m^3, the lower detection limit, throughout the period.

Deposition of weapons tests fallout during the first half of 1967 totaled 23 nCi/m^2 at the plant perimeter locations and 20 nCi/m^2 at 25-mile radius locations; comparable values for the last half of 1966 were 27 and 21 nCi/m^2. Deposition at each sampling location is presented in table 8.

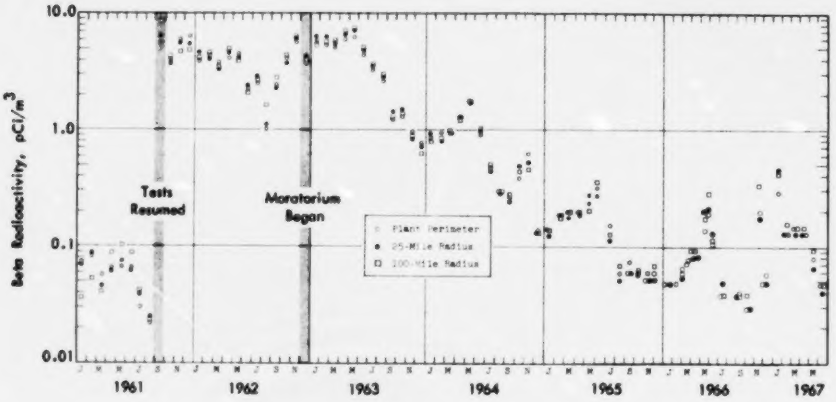

Figure 7. Influence of weapons tests

Table 8. Total fallout deposited, Savannah River Plant, January–June 1967

Radionuclide	Deposition (nCi/m^2)																	
	Plant perimeter locations						25-mile radius locations											
	A	B	C	D	E	Average	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Highway 301	Average
Alpha [a]	3.28	2.35	3.78	2.74	3.63	3.17	0.62	2.20	1.74	1.89	2.43	3.17	1.39	2.05	2.01	2.08	1.97
Strontium-89	1.51	0.96	1.93	1.00	1.78	1.43	0.77	0.66	1.62	0.96	0.62	0.77	0.97	1.93	1.35	1.43	1.12
Strontium-90	0.54	0.46	0.42	0.58	0.62	0.54	0.42	0.66	0.54	0.42	0.69	0.58	0.46	0.54	0.50	0.42	0.54
Iodine-131	1.81	1.70	0.54	1.70	2.05	1.54	2.39	0.62	1.47	1.27	3.17	2.01	1.70	2.39	0.39	1.85	1.74
Cesium-137	1.08	0.85	0.93	0.96	1.12	1.00	0.69	1.00	0.85	0.95	0.93	1.00	0.77	0.77	0.69	0.85	0.85
Cerium-141, -144	2.20	1.20	1.74	1.16	1.35	1.54	1.00	1.24	1.89	1.08	2.01	1.51	1.70	1.70	0.85	1.54	1.47
Ruthenium-103, -106	3.59	2.78	3.13	4.05	3.28	3.36	2.62	1.81	2.74	1.97	5.29	3.47	1.74	3.01	2.43	2.47	2.74
Barium-lanthanum-140	2.78	3.40	3.28	6.60	7.03	4.63	9.50	2.32	2.86	1.39	5.21	4.01	2.47	10.38	3.74	4.59	4.63
Zirconium-niobium-95	1.70	0.81	1.16	1.00	1.16	1.16	0.84	0.93	1.47	1.16	1.78	1.35	1.47	1.08	0.85	1.51	1.24
Beryllium-7	8.22	8.03	5.91	5.17	10.58	7.57	4.90	4.48	6.21	3.71	6.64	11.19	5.67	5.37	5.79	7.41	6.14

[a] Multiply by 10^{-3}.

Algae and fish in Savannah River

Fish, predominantly bream, and indigenous algae, primarily green (*Vaucheria*) and blue-green (*Phormidium*), were collected weekly, upstream from, adjacent to and downstream from the Savannah River Plant. Determination of radionuclides in algae is important because algae concentrate certain radionuclides and also because of the role of algae in the food chain of aquatic organisms. Beta-particle con-

Table 9. Radioactivity in air, Savannah River Plant, January–June 1967

Filter analysis	Average concentration (pCi/m³)																
	Plant perimeter locations						25-mile radius locations										
	A	B	C	D	E	Average	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Highway 301	Average
Alpha particle emitters [a] (multiply by 10^{-3})																	
Maximum	1.2	1.4	1.5	0.9	1.0	------	1.2	2.8	1.1	1.2	2.4	1.4	0.9	1.0	1.2	1.1	------
Minimum	0.3	0.4	ND	.3	0.3	------	ND	ND	ND	ND	0.3	0.3	ND	ND	0.3	ND	------
Average	.7	.7	0.7	.6	.6	0.6	0.6	0.6	0.6	0.6	.8	.9	.4	.6	.6	0.6	0.6
Nonvolatile beta-particle emitters [b]																	
Maximum	.53	.59	.41	.44	.61	------	.84	.32	.68	.81	.42	.66	.41	1.39	.93	.31	------
Minimum	.02	.02	.03	.02	.02	------	.02	.02	.01	.02	.02	.03	.02	.02	.02	.02	------
Average	.14	1.3	.11	0.13	.14	0.13	.18	.12	.16	.17	.13	.14	.15	.21	.17	.12	0.1
	Composite sample						Composite sample										
Specific radionuclides (averages)																	
Strontium-89, -90	0.007						0.008										
Cesium-137	.008						.006										
Cerium-141, -144	.022						.020										
Ruthenium-103, -106	.030						.029										
Zirconium-niobium-95	.009						.006										

[a] Sensitivity of analysis— 3.0×10^{-4} pCi/m³; ICRP Maximum Permissible Concentration: 0.04 pCi/m³.
[b] Sensitivity of analysis—0.006 pCi/m³; ICRP Maximum Permissible Concentration: 100 pCi/m³.
ND, less than sensitivity of analysis.

centrations in algae and fish adjacent to and downstream from SRP indicate some minor contribution by SRP. Although measurably higher than similar material collected at the control station 3 miles upstream from SRP, the slight increase is of no biological significance.

Specific radionuclide analyses were made on algae and fish collected from the Savannah River. Radiocesium and radiostrontium were found consistently in river algae; whereas cerium–141–144, chromium–51, zirconium–niobium–95, manganese–54, zinc–65, and cobalt–60 were detected less frequently. Also, radiostrontium (maximum, 20 pCi/g, wet weight) was detected in bone tissue of river fish, and radiocesium (maximum, 78 pCi/g, wet weight) was detected in the flesh tissue. Radiozinc and phosphorus–32 were detected less frequently in these tissues. The maximum concentrations of phosphorus–32 detected in bone and flesh tissues of river fish were 719 pCi/g and 5 pCi/g, respectively.

Water monitoring

The plant site is drained by five streams which flow several miles through the reservation before reaching the river (figure 8). In January 1965, the Beaufort-Jasper Water Authority began operation of a new treatment facility to furnish drinking water, partially supplied from the Savannah River, to most of

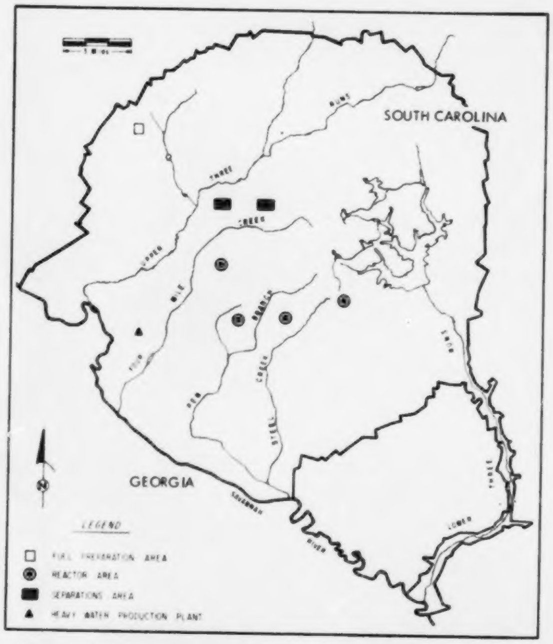

Figure 8. SRP production areas and effluent streams

Beaufort County, South Carolina. Water is supplied through a new canal from the river at a location about 90 miles below the SRP. The city of Savannah also supplements its domestic well water supply with river water during periods of peak demand.

Communities near SRP get domestic water from deep wells or surface streams. Public water supplies from 14 surrounding towns were collected and analyzed in April. There was no evidence that SRP contributed radioactivity to drinking water supplies; concentrations of alpha radioactivity (1.4 pCi/liter) and beta radioactivity (6 pCi/liter) were essentially the same as those observed before plant startup.

River water, analyzed weekly, was sampled continuously at four locations, as shown in figure 8. Average concentrations of specific radionuclides found in river water during January–June 1967 are in table 11.

Cesium-137, tritium, and trace amounts of chromium-51, and strontium-90, released mainly from reactor areas, were the radionuclides of SRP origin detectable in river water at the downstream location. Strontium-90 and tritium from worldwide fallout were also detected in river water upstream from SRP. The tritium concentrations in finished water collected from the Beaufort-Jasper Water Plant averaged 4,800 pCi/liter (0.5 percent of the MPC) during the 6-month report period.

Tritium, a beta-particle emitter and the most abundant radionuclide released to the river, is produced by neutron irradiation of heavy water moderator in the reactors. Chromium-51, the second most abundant radionuclide released to the river, is produced by neutron irradiation of stable chromium (a component of the stainless steel used in reactor parts). Tritium and chromium-51 are among the least dangerous of all radionuclides because neither concentrates in body tissues. The tritium and chromium-51 concentrations in river water averaged 1.2 and 0.001 percent of the MPC, respectively.

Milk

Milk was sampled at three dairies within a 25-mile radius of SRP, as shown in figure 9. Samples which were collected biweekly, were analyzed for tritium, radiocesiums, and radioiodine. Strontium-90 determinations were made quarterly. Milk produced in the area and sold by major distributors was also analyzed for these radionuclides. Results from analyzing milk for radioactivity during January–June 1967 are in table 10.

Average concentrations of three radionuclides in milk (30 pCi/liter for cesium-137, 20 pCi/liter for strontium-90, and less than 7 pCi/liter for iodine-131) were consistent with values reported by the U.S. Public Health Service for most sections of the United States during the first half of 1967. Tritium in local milk, when present, is assumed to be associated with plant operations. The average tritium level was less than the sensitivity of the analysis which allows detection of concentrations of 3,000 pCi/liter (1 percent of the MPC for water).

Table 10. Radioactivity in milk from local dairies, Savannah River Plant, January–June 1967

Location of local dairies	Concentration (pCi/liter)										
	Tritium [a]			Strontium-90 [b]		Iodine-131 [c]			Cesium-137 [d]		
	Maximum	Minimum	Average	March	June	Maximum	Minimum	Average	Maximum	Minimum	Average
Aiken	6,000	<3,000	<3,000	21	18	240	<5	8	<30	<30	<30
North Augusta	7,000	<3,000	<3,000	20	NS	23	<5	<5	<30	<30	<30
Waynesboro	<3,000	<3,000	<3,000	NS	NS	57	<5	<5	<30	<30	<30
Major distributors [e]	5,000	<3,000	<3,000	19	24	330	<5	10	<30	<30	<30

[a] Sensitivity of analysis—3,000 pCi/liter.
[b] Sensitivity of analysis—1.0 pCi/liter.
[c] Sensitivity of analysis—5.0 pCi/liter.
[d] Sensitivity of analysis—30 pCi/liter.
[e] Milk produced in local dairies, but sold by major distributors.
NS, no sample collected.

Vegetation

Radioactive contamination of growing plants may result from deposition on foliar surfaces or absorption of radioactive materials from the soil.

Grass samples were collected at seven locations along the plant perimeter and at nine other locations along a 25-mile radius route. (These are not designated on figure 5). Samples from each quadrant of the plant site and of the surrounding area were composited for monthly analysis. Radionuclides in grass samples were from weapons test fallout. Alpha-particle emitters averaged 0.2 pCi/g at the plant perimeter and 25-miles radius locations as compared to 0.1 pCi/g during the last half of 1966; gamma-ray emitters averaged 32 and 37 pCi/g, respectively, as compared to 24 and 21 pCi/g for the last half of 1966.

Environmental gamma radiation levels

Table 11. Average concentration of radionuclides in Savannah River water, January–June 1967

Radionuclide	Concentration (pCi/liter)			
	Sensitivity of analysis	Control (3 miles upstream from plant)	Highway 301 (10 miles downstream from plant)	Percent MPC at Highway 301
Tritium	600	1,200	12,200	1.2
Ruthenium-103, -106	3.2	<3.2	<3.2	<0.10
Cerium-141, -144	2.5	<2.5	<2.5	< .08
Cesium-134, 137	0.6	<0.6	2.5	0.4
Neptunium-239	2.2	<2.2	<2.2	< .01
Barium-lanthanum-140	1.6	<1.6	<1.6	< .02
Zirconium-niobium-95	.5	< .5	<0.5	< .002
Chromium-51	4.3	<4.3	5.2	.001
Strontium-89	.3	< .3	< .3	....
Iodine-131	.5	< .5	< .5	....
Strontium-90	.01	.8	1.3	....
Cobalt-60	1.4	<1.4	<1.4	< .007
Zinc-65	1.1	<1.1	<1.1	< .004
Manganese-54	.4	< .4	< .4	< .001

Monthly measurements of environmental gamma radiation were made with thermoluminescent dosimeters. The January–June 1967 data (shown in table 12), are characteristic of measurements observed at individual stations for the past several years.

Recent coverage in ***Radiological Health Data and Reports:***

Period	Issue
January–June 1966	February 1967
July–December 1966	September 1967

Table 12. Environmental gamma radiation, Savannah River Plant, January–June 1967

	Exposure (mR/day)																
	Plant perimeter locations						25-mile radius locations										
	A	B	C	D	E	Average	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Highway 301	Average
Maximum	0.33	0.29	0.42	0.27	0.30	......	0.41	0.24	0.32	0.31	0.33	0.38	0.29	0.40	0.44	0.26	......
Minimum	.22	.17	.21	.16	.12	......	.17	.15	.18	.17	.19	.19	.17	.16	.18	.15	......
Average	.27	.25	.30	.23	.22	0.25	.25	.17	.23	.24	.25	.23	.24	.24	.30	.22	0.24

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Reported Nuclear Detonations, January 1967

The U.S. Atomic Energy Commission announced four underground nuclear detonations during January 1968. On January 18, 1968 an underground nuclear test of low yield (less than 20 kilotons TNT equivalent) was conducted at the AEC Nevada Test Site. Some radioactivity was accidentally released as a result of this test. While most of this radioactivity was deposited within the test site, some low level radioactivity was detected on the ground southwest of the site. The highest levels of radioactivity offsite were determined to be 0.7 milliroentgen per hour at Danby Ranch, which is less than 10 miles from the test site. This level of radioactivity presents no health hazard.

On January 19, 1968, an underground nuclear test of low-intermediate yield (20 to 200 kilotons TNT equivalent) was conducted at the Nevada Test Site.

On January 19, 1968, a nuclear test of intermediate yield (200 kilotons to 1 megaton TNT equivalent) was conducted underground by the AEC in the upper Hot Creek Valley of central Nevada.

The purpose of the test was to provide earth shock measurements to help determine whether the area is suitable for nuclear testing at higher yields than are possible at the Commission's permanent Nevada Test Site in the southwestern part of the State.

A decision on such use of the area must await analysis of data from this test and from other studies of the area.

On January 26, 1968, an underground nuclear test of low yield (less than 20 kilotons TNT equivalent) was conducted at the Nevada Test Site. This nuclear excavation experiment was part of the Plowshare Program to develop peaceful uses of nuclear explosives. The detonation was carried out at a buried depth of 170 feet and had a yield of about 2.5 kilotons. A crater about 125 feet deep and 400 feet in diameter was produced. The purpose of this experiment (called "Project Cabriolet") is to develop nuclear excavation technology and to provide information about cratering effects in hard dry rock.

Errata

Errata to article "Measurements of X-Ray Exposure from a Home Color Television Receiver" by Rechen, Lee, Schneider and Briscoe in *Radiological Health Data and Reports, Vol. 8*, December 1967, pp. 687–697.

Page i, Contents, change spelling of author's name from "Brisco" to "Briscoe"

Page 687, 1st column, 2nd paragraph, 3rd line—change "loaded" to "loaned"

Page 687, 2nd column, last paragraph—change sentence to read as follows: "X-ray exposure rates from the viewing faceplates of the cathode ray tubes under all typical operating conditions were well below NCRP recommendations."

Page 688, 1st column, 3rd paragraph, 5th line—change word from "on" to "or"

Page 690, table 1—change "C." in the heading of the 2nd column to "V."

Page 691, table 2, footnote "c", 2nd line—change word "roster" to "raster"

Page 692, 1st column, last paragraph, 4th line—change both references from table "4" to table "3"

Page 692, 2nd column, change first equation as follows:

$$R_{30} = R_{117} \times \left(\frac{117}{30}\right)^2$$

Page 692, last paragraph, 1st line—change the reference from table "3" to table "4"

Page 693, 1st column, 2nd paragraph—change the reference in line 3 from footnote "a" to footnote "b"

Page 695, 2nd column, 2nd paragraph—change the sentence starting on line 13 to read as follows: "The beam intensity decreases faster than the "inverse square" of distance because of air absorption and scatter."

Page 696, 1st column, 1st paragraph—change first line to read: "mR/hour at 85 cm was 43.5 percent of the ex-"

Page 696, 2nd column, last paragraph—add a period after word "layers" in 6th line. Delete last sentence.

Page 697, 1st column—delete rest of sentence continued from page 696.

Page 697, 2nd column, 1st line—correct spelling of word "planed" to "planned"

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

COMPARISON OF ENVIRONMENTAL RADIOACTIVITY LEVELS AFTER FOREIGN NUCLEAR WEAPONS TESTS OF MAY 9, 1966, AND DECEMBER 27, 1966. *David R. Snavely* and *Warren A. Brill. Radiological Health Data and Reports, Vol. 9,* February 1967, pp. 63–

The environmental radioactivity levels following foreign nuclear weapons tests of May 9, 1966 and December 27, 1966 are compared, and the influence of dairy practices and weather conditions on levels of iodine–131 in milk are discussed. After the former test the highest monthly deposition by precipitation occurred in the mid-section of the United States south of the Great Lakes (576 nCi/m^2 at Jefferson City, Mo.) and in the northeastern section of Florida. The highest monthly deposition after the latter test occurred along the northern section of the west coast (2,545 nCi/m^2 at Portland, Ore.), northern Utah, the area west of Lake Michigan and in northern Vermont. Following the December test, the highest gross beta radioactivity of surface air particulates (119 pCi/m^3 at Las Vegas, Nev.), the highest gross beta deposition by precipitation and the highest contribution of nuclides belonging to volatile decay chains (including iodine–131), were found. The highest estimated cumulative iodine–131 intake from drinking 1 liter of milk per day (9,300 pCi/liter) occurred after the May test. This appeared to result from different dairying practices being used at the time of the two tests, and the more rapid elimination of iodine–131 from the cows' feed after the December test.

KEYWORDS: Beta radioactivity, fallout, iodine–131, milk, nuclear weapons tests, pasteurized milk network, pasture half-time, precipitation.

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RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 9, Number 3, March 1968

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

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Reports

Polonium–210 in Tobacco

Stuart C. Black and *Erich W. Bretthauer* [1]

Variations of polonium–210 content in tobacco, the amount of polonium–210 in various fractions of smoked cigarettes and changes in polonium–210 content of mainstream smoke caused by variation in the smoking procedure have been determined. The average polonium–210 content for whole cigarettes was found to be 0.483 pCi/gram and 0.477 pCi/gram for butts. No polonium–210 enrichment in the butt of cigarettes during smoking was found. Polonium–210 content and concentration in mainstream smoke increases with puff size.

The initial paper of Radford and Hunt (*1*) reporting the presence of polonium–210 in cigarettes and the possible effects of the alpha particles as a cocarcinogen for initiating lung cancer in cigarette smokers prompted many experiments which have attempted to define the problem more exactly (*2–11*). Because of the uncertainty in lung deposition, equilibrium rates, smoking procedures and dose calculations, some disagreement about the significance of polonium–210 in tobacco has arisen (*12*). An experimental program was undertaken to determine the variation of polonium–210 content in tobacco, the amount of polonium–210 in various fractions of smoked cigarettes and changes in polonium–210 content of mainstream smoke caused by variation in the smoking procedure.

Methods

All paper, butt, filter, and tobacco samples were wet ashed by the nitric- perchloric-acid procedure (*13*). After plating on silver foil, the samples were counted in an internal proportional counter operating on the alpha-particle plateau. Operating on this plateau, up to 5,000 dpm of beta radioactivity contribute no counts to the alpha-particle count of the foil. The two alpha-particle counters used in this study had background count rates of 1.8 and 1.9 counts/hour and had an efficiency of 45.9 percent as determined by counting a calibrated aged radium D–E–F source. Reagent blanks, when run through the same glassware used for samples, contributed no alpha radioactivity above background when counted up to 70 hours. Recovery of added polonium–210, carried through the entire digestion and plating procedure, was quantitative. All samples were counted long enough to obtain at least 500 total counts.

A control sample consisting of 25 pounds of tobacco was prepared for internal quality control. This sample will also be used to provide aliquots for analysis by other laboratories.

If the results are reported for cigarettes only, *e.g.*, pCi/cigarette, then a consistent weight basis is unimportant, but where comparisons are to be made between portions of a cigarette, or among cigarettes, cigars, and pipe tobacco, the weight basis becomes important. All results expressed as "per gram" are based on the weight of the tobacco after drying under reduced pressure (15 mm Hg and 43° C.).

In all experiments on smoking, a standard smoking procedure was followed using a commercial smoking machine.[2] The smoking machine is designed to take a constant puff on each of four cigarettes once each minute for collection of smoke. The volume of the puff may be varied from 10 to 65 cm^3 and the duration of the puff may be varied from less than one second to four seconds, depending on the vol-

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[1] Dr. Black is project director and Mr. Bretthauer is project chemist, Southwestern Radiological Health Laboratory, Las Vegas, Nev.

[2] "American Smoker," Phipps and Bird, Inc., Richmond, Va.

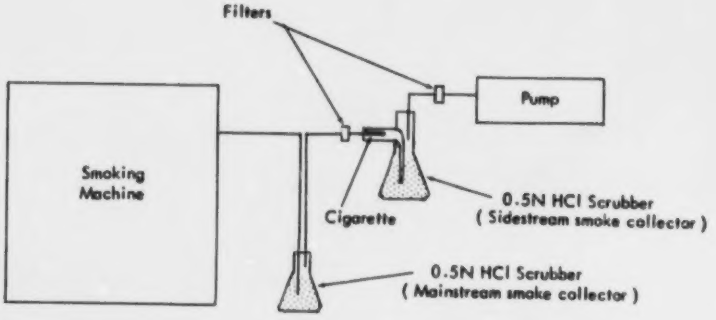

Figure 1. Apparatus for polonium-210 balance study

ume of the puff. The puff is produced by a reduction in pressure occurring when the water column in a burette is allowed to fall. The volume of the puff is controlled by regulating the rate at which water flows from the burette. The standard smoking procedure was eight puffs of two seconds duration, 36 cm^3 per puff, with a 60-second interval between puffs (*14*). This procedure was modified only in the experiments on the effect of puff size on polonium-210 in mainstream smoke. The arrangement of apparatus for collecting mainstream and sidestream smoke during balance studies is shown in figure 1. "Mainstream" means smoke taken into the mouth. "Sidestream" is smoke from the burning tip not taken into the mouth. The scrubbers, which collected smoke and polonium-210, contained 150 ml of 0.5 *N* HCl. The filters, which collected particulates and polonium-210, consisted of Whatman 541 prefilters backed by 0.45 micron Metricel filters, type GA-6.

A limited amount of data was collected to check on the puff volume of smokers. The apparatus used for this experiment is shown in figure 2. The procedure for measuring puff volume was as follows: the subject was allowed to draw several cigarette puffs with the stopper removed; the stopper was then quickly inserted just prior to a puff and the maximum height of the water column read. This procedure was repeated at least four times.

Temperature measurements were made on cigarettes during smoking by use of 0.003-inch diameter Pt-10% Rh thermocouples and a 10 mV recorder. The thermocouple was inserted in the center of the cigarette (pushed into the cigarette from the side) 20 mm behind the tip. The temperature was measured as the coal passed through the portion containing the thermocouple. The temperature of mainstream smoke was measured by placing the thermocouple immediately behind the cigarette during smoking.

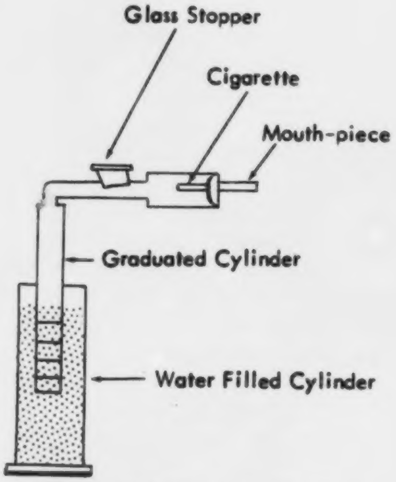

Figure 2. Puff measuring apparatus

Sampling for polonium-210 in the laboratory air was performed with air samplers equipped with Whatman 541 prefilters followed by 0.45 micron membrane filters. The samplers were run for periods of 12 to 24 hours at flow rates of either 20 liters/min or 100 liters/min. These samples were taken to determine the contribution, if any, of polonium-210 to the cigarettes by the atmospheric air drawn through them during smoking.

The efficiency of commercial cigarette filters for removal of polonium-210 from mainstream smoke was determined by removing the filters from some cigarettes in a pack, smoking the cigarettes by the standard method, and measuring the polonium-210 in the mainstream smoke. Cigarettes from the same pack were analyzed, with the filters intact, by the same method for comparative purposes. The three common types of filters (cellulose, charcoal impregnated paper, and granular charcoal) were checked for filtration efficiency.

Results

The results of tobacco drying experiments indicate that a 25-hour drying time was required to attain constant weight. The samples consisted of five cigarettes each. The samples were transferred to a desiccator and allowed to cool 30 minutes before weighing.

Subsamples of the 25-pound control sample were analyzed for polonium-210 and also for homogeneity. Polonium-210 results of five random samples show an average polonium-210 content of 0.559 ± 0.010 pCi/gram of tobacco. These results indicate a high degree of homogeneity of the sample.

Two experiments were performed to determine the extent of enrichment of polonium-210, if any, in the cigarette butt. In the first experiment, a total of 12 cigarettes was smoked by the standard smoking procedure and the butts analyzed for polonium-210. In the second experiment, cigarettes were smoked and sufficient butts collected to give a total of 200 mm of length. Polonium-210 analyses on whole cigarettes were also made. The cigarettes weighed between 0.96 and 1.01 grams and the counting error was about 0.018 pCi/gram of 0.003 pCi/mm. The average polonium-210 content for whole cigarettes was 0.483 pCi/gram (0.0075 pCi/mm) and 0.477 pCi/gram (0.0076 pCi/mm) for butts. On both the unit weight and unit length bases, there was no polonium-210 enrichment in the butt of the cigarette during smoking. This conclusion was further verified by collecting sequentially puffs of smoke on separate filters. The results in table 1 show the concentration of polonium-210 in mainstream smoke to be constant, or within two standard deviations of the mean.

Table 1. Mainstream polonium-210 as a function of puff number

Filter position	Puffs collected	Number cigarettes	Average pCi/puff
1	1-3	17	[a] 0.0035±0.0002
2	4-5	17	.0037± .0002
3	6-7	17	.0044± .0002
4	8-9	[b] 11	.0042± .0002

[a] ± value is 1σ counting error.
[b] a loss of six filter papers occurred on composition.

The maximum coal temperatures during machine smoking of 10 cigarettes averaged 720° C. with a range of 664° to 812° C. The temperature of mainstream smoke is shown in figure 3 as a function of number of puffs. The smoke entering the mouth remains at constant temperature for the first six standard puffs.

The results of the balance study on smoked cigarettes are shown in table 2. The total po-

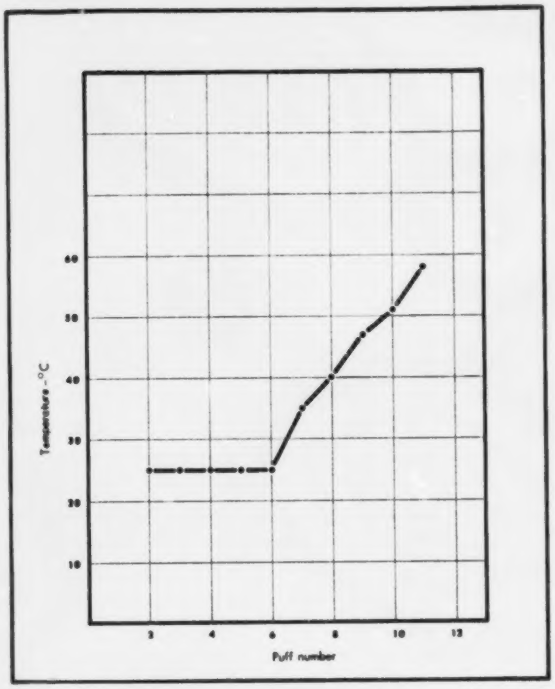

Figure 3. Mainstream smoke temperature as a function of puff number

Table 2. Balance study on artificially smoked cigarettes for polonium-210 in pCi/cigarette[a]

Number of cigarettes	Butts	Ashes	Sidestream	Mainstream	Total recovered
2	[b]0.173 ± 0.014	0.065 ± 0.006	0.221 ± 0.006	0.029 ± 0.002	0.488 ± 0.017
2	.175 ± .014	.067 ± .007	.216 ± .006	.021 ± .002	.479 ± .017
2	.153 ± .014	.091 ± .008	.230 ± .007	.029 ± .002	.503 ± .018
2	.156 ± .014	.072 ± .006	.224 ± .006	.029 ± .002	.481 ± .017
Average	0.165 ± 0.010	0.074 ± 0.021	0.223 ± 0.010	0.027 ± 0.007	0.489 ± 0.017

[a] The polonium-210 content of whole cigarettes from the same pack was 0.475 ± 0.108 pCi/cigarette.
[b] ± value is 1σ counting error.

lonium-210 recovered from the various fractions represents quantitative recovery of the amount in unsmoked cigarettes from the same pack, within the counting error limits.

The effect of puff size on polonium-210 content in mainstream smoke is shown in figure 4. The smoking procedure was standard, only the volume of each puff being changed. The variation in puff size for humans smoking cigarettes has been reported as 27 to 61 cm³ (*15*). This range is indicated on figure 4. Data on puff size, using the apparatus shown in figure 2, were obtained from three subjects, as shown in table 3, and are in reasonable agreement with this range.

Table 3. Cigarette puff volume of laboratory personnel

	Subject A (cm³)	Subject B (cm³)	Subject C (cm³)
	41	39	—
	38	43	68
	39	46	69
	39	46	71
	38	45	70
Average	39	44	70

The data in figure 4 show that polonium-210 content not only increases with puff size but also the concentration increases. The routine smoking procedure was 8 puffs per cigarette, regardless of puff size. Therefore, if each of the puff sizes in figure 4 is multiplied by 8 puffs per cigarette to get the total volume inhaled, and the total pCi in mainstream smoke is divided by this volume, then the concentrations obtained are as shown in table 4. A probable explanation for this effect is that the ratio of smoke to air increases as the volume per puff increases.

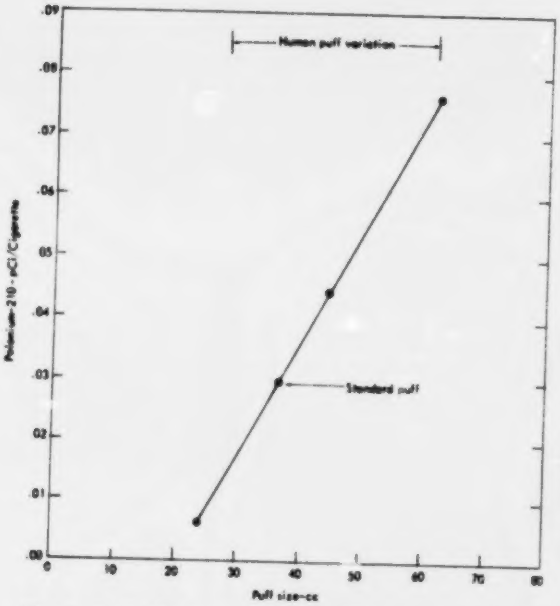

Figure 4. Variation of polonium-210 in mainstream smoke as a function of puff size

Table 4. Concentration of polonium-210 in mainstream smoke (8 puffs)

Puff size (cm³)	Inhaled volume (cm³)	Total pCi	pCi/cm³
25	200	0.0074	0.000037
36	288	.0290	.000100
44	352	.0441	.000125
62	496	.0762	.000153

The polonium-210 content of air in the laboratory is indicated by the data in table 5. The concentration ranged from 0.52 to 3.02 fCi/m³. This suggests that the volume of air used during smoking a cigarette would contribute no measurable polonium-210 to either the mainstream smoke or the butt of the cigarette.

Table 5. Polonium-210 analysis of laboratory air

Collection date (1966)	Type of collection	Volume (m^3)	Concentration (pCi/m^3)
1/5	[a]LV	21.1	2.99 x 10^{-3}
1/8	LV	14.4	3.02 x 10^{-3}
2/17	[b]HV	103.7	0.59 x 10^{-3}
2/18	HV	140.4	.62 x 10^{-3}
2/21	HV	140.7	.52 x 10^{-3}
2/23	HV	132.6	.78 x 10^{-3}
2/28	HV	153.5	.62 x 10^{-3}
2/28	LV	30.1	.75 x 10^{-3}

[a] LV, low volume (1 cubic foot/minute).
[b] HV, high volume (12 cubic feet/minute).

The polonium-210 content in the butts and collected ashes of cigarettes smoked by machine is compared in table 6 to similar samples from cigarettes smoked by laboratory personnel. These data indicate that smoking by machine provides a reasonable duplication of the results obtained from human smoking.

Table 6. Polonium-210 content in butts and ashes after human or machine smoking

Category	Human smoker [a]		Machine smoker [a]	
	Trial 1	Trial 2	Trial 1	Trial 2
Number of cigarettes	8	6	15	15
Butt length (mm)	28-34	28-34	22-32	22-32
Butt-pCi/cigarette	0.165	0.215	0.148	0.168
Butt-pCi/gram	.469	.481	.524	.473
Ashes-pCi/cigarette (average)	0.083		0.108	
Ashes-pCi/gram (average)	.989		1.06	

[a]The same smoker (human and machine) was used for each trial.

The polonium-210 content of various brands of cigarettes, cigars, and pipe tobacco is shown in tables 7 and 8. The polonium-210 content of several foreign brands of cigarettes is shown in table 9. The cigarette papers from four brands of cigarettes (100 of each) averaged only 0.003 pCi per cigarette.

Table 7. Polonium-210 content of domestic cigarettes (non-filter type)

Brand	Number of cigarettes	Concentration (pCi/cigarette)	Concentration (pCi/gram)
A	7	0.588	[a] 0.608 ± 0.015
B	10	.544	.496 ± .014
C	10	.527	.518 ± .012
D	10	.587	.566 ± .012
E	10	.600	.568 ± .014
F	10	.585	.552 ± .015
G	10	.87	.422 ± .012
H	11	.481	.430 ± .011
Average		0.537	0.520

[a] ± value is 1σ counting error.

Table 8. Polonium-210 content of domestic tobaccos

Type	Number of brands	Number per sample	Number of replicates	Average (pCi/g)	Range (pCi/g)
Cigarettes	8	5	2	0.516	0.375-0.609
Small cigars	2	1	2	.501	.497- .503
Medium cigars	5	1	2	.563	.480- .811
Large cigars	3	1	2	.376	.284- .434
Pipe tobacco	25	[a]7	2	.399	.235- .540

[a] grams.

Table 9. Polonium-210 content of foreign cigarettes

Country	Brands analyzed	Average (pCi/cig)	Range (pCi/cig)	Average (pCi/g)	Range (pCi/g)
England	7	0.467	0.232-0.619	0.461	0.363-0.589
Canada	2	.214	.206- .222	.255	.223- .288
Egypt	1	.381		.443	
Finland	2	.291	.266- .317	.630	.469- .792
Germany	1	.518		.564	
Japan	4	.605	.454- .890	.596	.399- .801
Norway	1	.231		.218	
France	1	.626		.560	
Phillipines	1	.290		.182	
Russia	1	.382		.600	

Table 10. Efficiencies of commercial filters in removing polonium-210 from mainstream smoke

Brand	Type filter	Concentration without filters (pCi/cm^3)	Concentration with filters (pCi/cm^3)	Percent removed
XP	Cellulose	[a]0.0301 ± 0.0017	[a]0.0170 ± 0.0012	43
XU	Cellulose	.0290 ± .0013	.0123 ± .0008	58
XK	Cellulose	.0324 ± .0013	.0154 ± .0009	52
XH	Charcoal paper; cellulose tip	.0290 ± .0016	.0165 ± .0009	43
XL	Cellulose; granular charcoal; cellulose tip	.0262 ± .0014	.0176 ± .0010	33
XPM	Charcoal; cellulose; granular charcoal; cellulose tip	.0267 ± .0016	.0179 ± .0009	33

[a] ± value is 1 counting error.

The effect of various types of commercial cigarette filters on the concentration of polonium-210 in mainstream smoke is shown in the data of table 10.

Discussion

Any program designed to measure human exposure from smoking cigarettes must use some uniform reference method of artificially smoking the cigarettes. The standard method used in these experiments is almost identical to one proposed by the Association of Official Analytical Chemists (AOAC) (*15*) but, more importantly, it is a reproducible method and the polonium-210 analysis of various fractions of the smoked cigarette is in reasonable agreement with similar analyses on cigarettes smoked by laboratory personnel. This latter point is illustrated by the data in tables 3 and 6.

An unexpected finding is suggested by the fact that there is no apparent polonium-210 enrichment of the butt as the cigarette is smoked. We would have suspected such an enrichment, reasoning that polonium-210 volatilized by the hot coal would redeposit as the smoke cooled in moving through the remainder of the cigarette. Figure 3 indicates that the temperature of mainstream smoke is near room temperature despite the fact that it is generated at a temperature of 720° C. Some of the possible reasons for the lack of redeposit of the volatilized polonium-210 are that it was generated as an uncharged particle which readily penetrated the cigarette tobaccos, or that it was attached to very small particles that also passed through the tobacco, or that it was bound up in some organic component of the smoke which carried it through the tobacco. The cellulose filters removed about 52 percent of the polonium-210 while the charcoal filters removed only about 36 percent. This is similar to the efficiency of removal of particulate matter by each type of filter.

Domestic cigarettes are fairly uniform in polonium-210 content, the range of the average values being 0.375 to 0.609 pCi/gram. The range, for the cigars analyzed, was 0.284 to 0.811 pCi/gram and for pipe tobaccos was 0.235 to 0.540 pCi/gram. If polonium-210 content in tobaccos proves hazardous on further experimentation, then tobaccos with low polonium-210 concentrations can be analyzed to determine which constituent, *i.e.*, species of tobacco or type of treatment is responsible for the low value. This may be a desirable first step in minimizing any hazard. The wide range of polonium-210 concentrations in foreign tobaccos (table 9) suggests that there may be species or farming practices or treatment procedures which modify the polonium-210 content. Samples of cured native tobaccos from many foreign producers are being analyzed to elucidate this point. In addition, smoking styles may modify the amount of inhaled polonium-210.

Determination of the alpha-particle dosage to the lung of the smoker is, of course, one of the primary goals of this research program. Direct data which could be used to calculate a lung dosage is not available, but an estimate of the maximum possible dosage for a heavy smoker can be made, as a guide for other estimates, by using some of the results herein. A lung model is not used because two important pieces of data are missing; *i.e.*, the particle size of the polonium in tobacco smoke and the solubility of the particles. To obtain the maximum dosage, assume:

1. The average value for domestic cigarettes is 0.516 pCi/gram (table 8).
2. The mainstream smoke contains 0.076 pCi/cigarette for 62 cm^3 puffs (figure 4).
3. A subject smokes 2 packs (40 cigarettes) per day.
4. Polonium-210 is retained in bronchi until decay.
5. One hundred percent of the polonium-210 is deposited in bronchi.
6. Redistribution by ciliar movement and other processes increases concentration in certain areas by a factor of 10 ("hot spots").
7. The bronchial epithelium exposed weighs 20 grams (*16*).

Assumption 4 takes into account the pulmonary clearance classification of inorganic compounds proposed by the Task Group on Lung Dynamics for Committee II of the ICRP (*17*). It is assumed the polonium-210 as it exists in conjunction with the tobacco smoke aerosol, falls in class Y, avid retention. As-

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sumption 5 reflects current thought in particle deposition; *e.g.*, the Task Group uses up to 89.6 percent deposition for 0.02 MMAD aerosols (*17*), while Jacobi calculated 80 percent total deposition for uncombined atoms (*18*). This implies that the radioactivity added per day will build up in the lung to a value equal to the radioactivity day/γ. The maximum dosage calculation is then:

$$\text{Dose} = \frac{(A)\ (B)\ (C)\ (D)\ (E)\ (F)}{(G)\ (H)\ (I)\ (J)}$$

where, for calculation of the maximum dose,

A = 0.076 pCi/cigarette (mainstream smoke concentration)
B = 40 cigarettes/day (number of cigarettes smoked)
C = 2.22 dpm/pCi (conversion factor)
D = 1440 min/day (conversion factor)
E = 5.3 MeV/disintegration (polonium-210 alpha-particle energy)
F = 1.6×10^{-6} erg/MeV (conversion factor)
G = 100 erg/gram-rad (conversion factor)
H = 0.005 days^{-1} (decay constant) = λ
I = 20 grams (bronchial epithelium weight)
J = 10^{-3} rad/mrad (conversion factor)

which yields,

maximum dose = 8.25 mrad/day

The "hot spot" correction would therefore be ten times this value, or 82.5 mrad/day.

A minimum dosage estimate for a heavy smoker can be made by assuming no buildup of polonium-210 in the bronchi, deposition of 25 percent, a 36 cm^3 puff size, and a "hot spot" concentration of 2. The dose rate then becomes 3.2×10^{-5} rad/day or 0.032 mrad/day.

The range of dose rates thus calculated (0.032 to 82.5 mrad/day) can be compared to the bronchial dose rate, resulting from the short-lived radon daughters, calculated by Jacobi (*18*) or 0.39 to 0.79 mrad/day. These calculations imply that a two-pack per day cigarette smoker will add an alpha-particle dose rate to his bronchial tissue which is somewhere between 0.1 and 100 times the background dose rate. If the smoker's average dose rate is near the middle of this range and if the relative biological effectiveness for bronchogenic cancer is as high as 10, then a significant hazard may exist.

Finally, we must compare our results with those of other workers in the field, *e.g.*, the data in references (*1*), (*5*) and (*8*). The values are not directly comparable because of differences in smoking procedure. Using the data in figure 4 though, an equation can be derived to correct the data if the number of puffs and the puff size are known, *viz*:

$$\text{fCi} = (0.236X - 5.0)(Y)$$

where,

fCi = femtocuries (10^{-15} curies) in mainstream smoke,
X = puff size in cm^3, and
Y = number of puffs per cigarette.

Adjusting the data in the references by use of this formula results in good agreement among the various authors.

Conclusions

A standard smoking procedure is a necessity if results of cigarette smoking are to be compared.

For a given number of puffs per cigarette, the amount of polonium-210 and its *concentration* in mainstream smoke increases with the size of an individual puff.

Polonium-210 released by the burning tobacco is not readily removed from the smoke by either the tobacco it is moved through or, to any great extent, by cigarette filters of *various* types.

The assumptions and calculations made in this report indicate that a subject smoking two packs per day of American cigarettes receives an alpha-particle dose rate to his bronchial tissue which is somewhere between a minimum of 0.1 and a maximum of 100 times the alpha-particle dose rate delivered by the short-lived daughter products of radon at normal atmospheric levels (*18*). There are so many unknowns in this field that an attempt to use more precise figures or a given lung model would imply that we know a lot more than we do about the deposition of polonium in lung as a result of cigarette smoking.

A reduction in alpha-particle dose rate to the lung tissues can be accomplished by selecting brands with a low polonium-210 concentration if it can be demonstrated that this concentration is a stable feature of individual brands.

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Data

SECTION I. MILK AND FOOD

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Federal and State agencies are involved in efforts to monitor continuously the dietary intake of radionuclides. The most direct measure of radionuclide intake would be obtained through radioanalysis of the total diet. Difficulties in obtaining specific dietary data impede this approach. An alternate method entails the use of indicator foods to arrive at an estimate of the total dietary radionuclide intake.

Fresh milk is one such indicator food. It is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides which appear in the diet. It also is one of the major sources of dietary intake for the short-lived radionuclides. For these reasons, fresh milk is the single food item most often used in estimating the intake of selected radionuclides by the general population and/or specific population groups. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of fresh milk.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission on Radiological Protection (*5, 6*).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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National And International Milk Surveillance

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide levels in milk. In addition to the programs reported, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in milk, HASL	July–December 1966	September 1967

1. Pasteurized Milk Network
November 1967

National Center for Radiological Health and *National Center for Urban and Industrial Health, PHS*

The Public Health Service's Pasteurized Milk Network (PMN) is designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 stations (figure 1) provides data on milk in every State, the Canal Zone, Puerto Rico, and Washington, D.C. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the January 1968 issue of *Radiological Health Data and Reports* (*1*). Reference should also be made to the February 1968 issue (*2*), in which changes in the interpretation and reporting of data were introduced.

Table 1. Analytical errors associated with determinations of radionuclide concentrations in a milk sample

Nuclide	Concentration (pCi/liter)	Error [a] (pCi/liter)	Concentration (pCi/liter)	Error [a] (percent of concentration)
Strontium-89	< 50	5	≥ 50	10
Strontium-90	< 20	2	≥ 20	10
Iodine-131	<100	10	≥100	10
Cesium-137	<100	10	≥100	10
Barium-140	<100	10	≥100	10

[a] Two standard deviations.

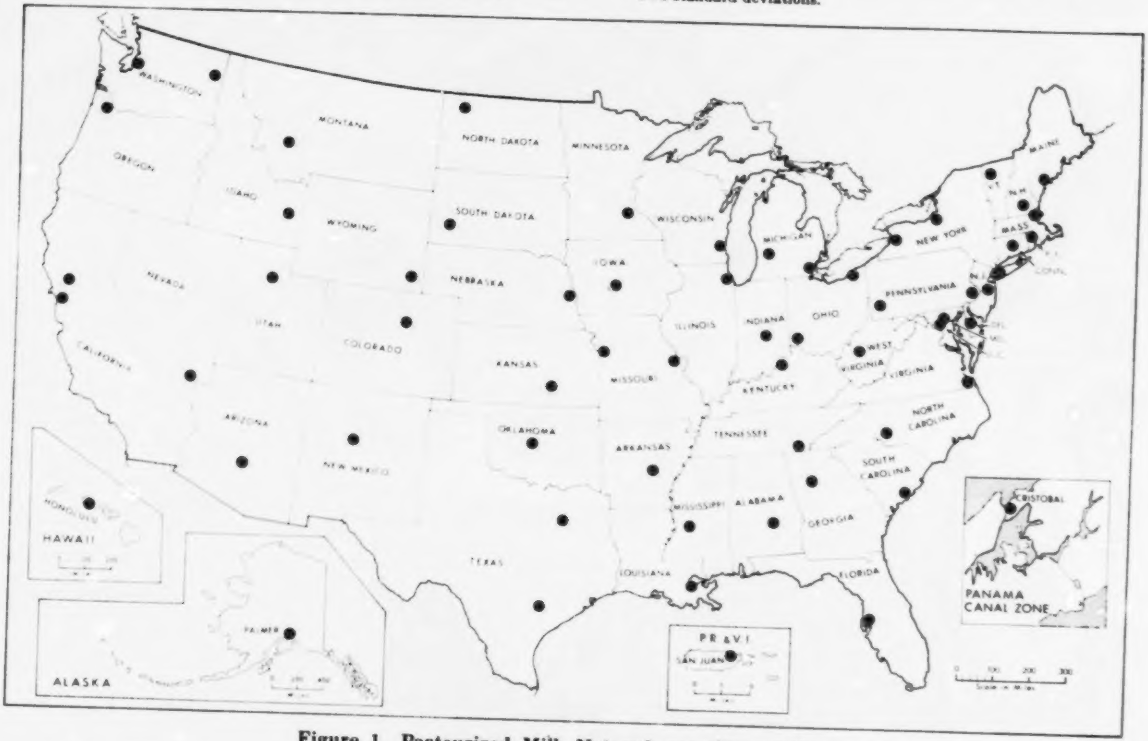

Figure 1. Pasteurized Milk Network sampling stations

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Table 2. Average concentrations of radionuclides in pasteurized milk for November 1967 and the 12-month period, December 1966 through November 1967[a]

Sampling locations		Concentrations (pCi/liter)									
		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
		Dec. 1966-Nov. 1967	November 1967[b]	Dec. 1966-Nov. 1967	November 1967	Dec. 1966-Nov. 1967	November 1967	Dec. 1966-Nov. 1967	November 1967	Dec. 1966-Nov. 1967	November 1967
Ala:	Montgomery	0	0	10	8	2	0	16	12	0	0
Alaska:	Palmer	0	0	8	5	0	0	21	12	0	0
Ariz:	Phoenix	0	0	2	1	0	0	1	3	0	0
Ark:	Little Rock	1	0	23	16	1	0	20	20	0	0
Calif:	Sacramento	2	0	3	2	2	0	3	0	0	0
	San Francisco	2	0	3	0	1	0	2	0	0	0
C.Z.:	Cristobal	0	0	4	1	0	0	22	13	0	0
Colo:	Denver	0	3	6	5	1	0	4	0	0	0
Conn:	Hartford	0	--	9	7	1	0	20	17	0	0
Del:	Wilmington	0	--	12	11	1	0	15	13	0	0
D.C.:	Washington	0	0	10	8	0	0	10	5	0	0
Fla:	Tampa	1	0	9	8	1	0	76	72	0	0
Ga:	Atlanta	0	0	16	14	3	0	24	19	0	0
Hawaii:	Honolulu	0	0	4	4	1	0	10	4	2	0
Idaho:	Idaho Falls	1	3	7	4	0	0	8	3	0	0
Ill:	Chicago	0	0	9	7	1	0	15	6	0	0
Ind:	Indianapolis	0	--	9	6	0	0	11	5	0	0
Iowa:	Des Moines	1	0	8	5	0	0	7	10	1	0
Kans:	Wichita	1	0	9	8	0	0	5	7	0	0
Ky:	Louisville	2	0	13	10	0	0	9	2	1	0
La:	New Orleans	1	0	25	20	1	0	29	20	1	0
Maine:	Portland	0	0	12	9	0	0	38	26	0	0
Md.:	Baltimore	0	0	11	10	0	0	13	5	0	0
Mass:	Boston	0	0	12	11	0	0	32	22	0	0
Mich:	Detroit	0	--	9	8	1	0	16	10	0	0
	Grand Rapids	0	0	10	10	0	0	19	13	0	0
Minn:	Minneapolis	1	0	14	12	0	0	14	7	0	0
Miss:	Jackson	2	0	19	16	2	0	17	10	0	0
Mo:	Kansas City	1	0	10	6	1	0	3	0	1	0
	St. Louis	2	0	10	10	0	0	7	7	1	0
Mont:	Helena	1	0	7	6	0	0	10	9	0	0
Nebr:	Omaha	0	0	9	7	1	0	6	3	0	0
Nev:	Las Vegas	0	0	2	0	0	0	2	0	0	0
N.H.:	Manchester	0	--	15	12	0	0	44	28	0	0
N.J.:	Trenton	0	0	10	11	0	0	16	16	0	0
N. Mex:	Albuquerque	0	3	3	0	0	0	1	0	0	0
N.Y.:	Buffalo	0	--	9	3	0	0	16	10	1	0
	New York City	0	0	11	8	0	0	18	15	0	0
	Syracuse	0	--	9	11	1	0	18	0	0	0
N.C.:	Charlotte	0	0	18	15	0	0	17	14	1	0
N. Dak:	Minot	3	2	15	10	0	0	14	8	0	0
Ohio:	Cincinnati	0	0	10	7	0	0	11	7	0	0
	Cleveland	0	--	10	11	1	0	15	8	0	0
Okla:	Oklahoma City	0	0	10	9	1	0	5	0	0	0
Ore:	Portland	2	0	8	6	2	0	14	11	0	0
Pa:	Philadelphia	0	--	10	8	1	0	13	9	0	0
	Pittsburgh	0	--	13	10	1	0	20	14	0	0
P.R.:	San Juan	2	0	5	5	0	0	15	14	0	0
R.I.:	Providence	0	0	11	10	0	0	25	11	0	0
S.C.:	Charleston	0	0	17	13	4	0	32	31	0	0
S. Dak:	Rapid City	2	3	12	10	1	0	13	7	1	0
Tenn:	Chattanooga	0	0	17	14	1	0	17	13	1	0
	Memphis	0	0	13	9	1	0	5	3	0	0
Tex:	Austin	0	0	4	3	3	0	4	0	0	0
	Dallas	0	0	9	6	2	0	7	0	0	0
Utah:	Salt Lake City	1	0	7	5	1	0	10	12	0	0
Vt:	Burlington	0	0	11	10	1	0	20	13	0	0
Va:	Norfolk	1	0	13	11	1	0	12	7	1	1
Wash:	Seattle	2	0	11	10	0	0	28	14	0	0
	Spokane	0	0	10	7	0	0	19	9	0	3
W. Va:	Charleston	0	0	12	9	0	0	8	3	0	0
Wisc:	Milwaukee	0	--	8	7	0	0	15	12	0	0
Wyo:	Laramie	0	0	6	4	0	0	5	0	0	0
Network average		1	0	10	9	1	0	15	10	0	0

[a] See text for averaging purposes.
[b] Dashes indicate no strontium-89 determinations were made on samples from station during month.

Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. Table 2 contains aver-

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ages for November 1967 and 12-month averages for the period, December 1966 through November 1967. The 12-month average facilitates evaluations of population exposure with respect to the guidance provided by the Federal Radiation Council. This suggests average total daily intakes averaged over periods of a year as an appropriate criterion (3). The average radionuclide concentrations are based on results obtained from samples collected weekly. Whenever weekly concentrations were less than or equal to the appropriate minimum detectable levels, zero was used for averaging purposes (2). At very low radionuclide concentrations this often results in averages lower than the minimum detectable concentration for a single sample but reflects that some of the samples making up the average were above the detectable level. The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable concentration in units of pCi/liter are: strontium–89, 5; strontium–90, 2; cesium–137, barium–140, and iodine–131, 10.

For comparative purposes, distributions of strontium–90 and cesium–137 are presented in tables 3 and 4 for November 1966, and June through November 1967. The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

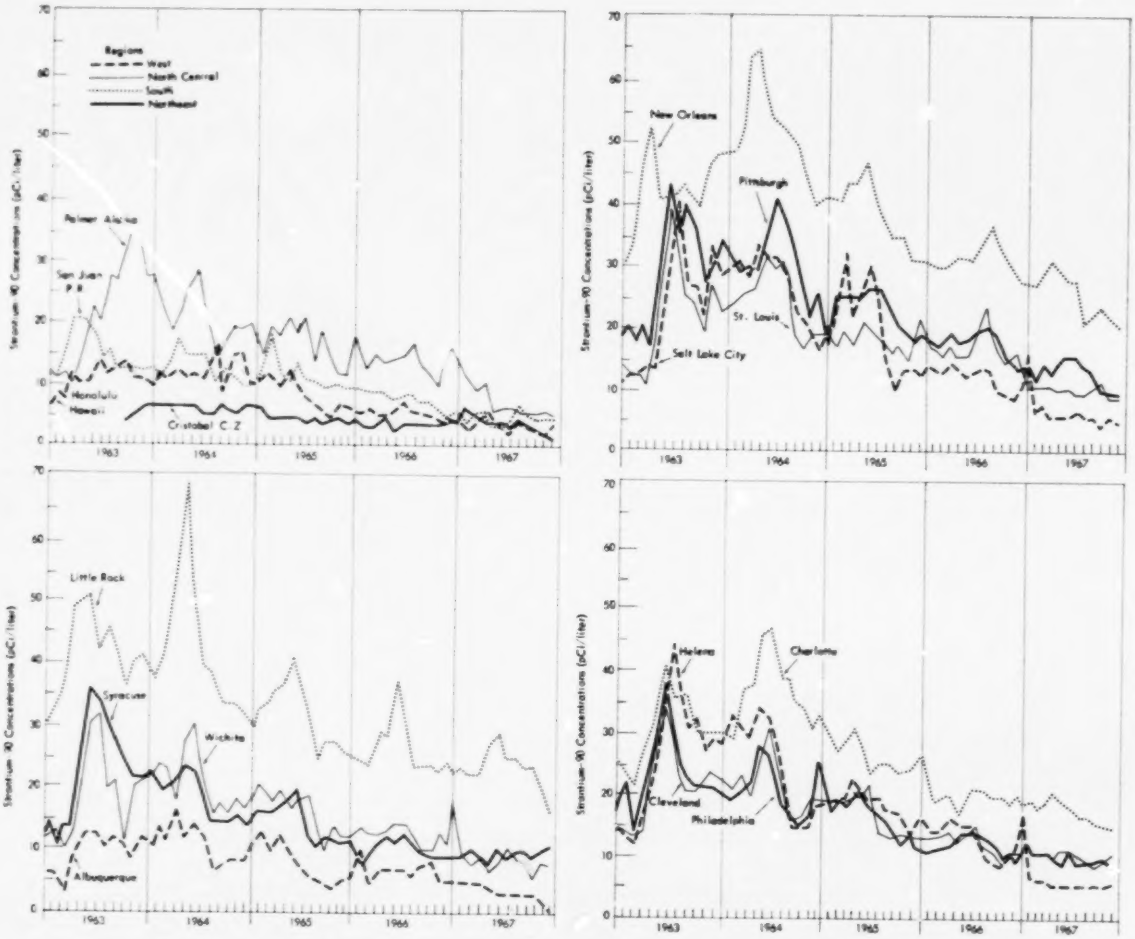

Figure 2. Strontium-90 concentrations in pasteurized milk, 1961–November 1967

Table 3. Frequently distribution, strontium-90 concentrations at PMN stations November 1966 and June-November 1967

Strontium-90 (pCi/liter)	Number of stations[a]						
	1966	1967					
	Nov	June	July	Aug	Sept	Oct	Nov
Under 10	19(30)	27(43)	25(40)	35(55)	37(59)	46(73)	43(68)
10–19	40(64)	34(54)	35(55)	26(42)	24(38)	16(25)	19(30)
20–29	4(6)	2(3)	3(5)	2(3)	2(3)	1(2)	1(2)

[a] Percentage of stations shown in parentheses.

Table 4. Frequency distribution, cesium-137 concentrations at PMN stations November 1966 and June-November 1967

Cesium-137 (pCi/liter)	Number of stations[a]						
	1966	1967					
	Nov	June	July	Aug	Sept	Oct	Nov
Under 50	61(97)	61(97)	61(97)	61(97)	62(98)	62(98)	62(98)
50–99	2(3)	2(3)	2(3)	2(3)	1(2)	1(2)	1(2)

[a] Percentage of stations shown in parentheses.

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2. Canadian Milk Network
November 1967[1]

Radiation Protection Division
Department of National Health and Welfare

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

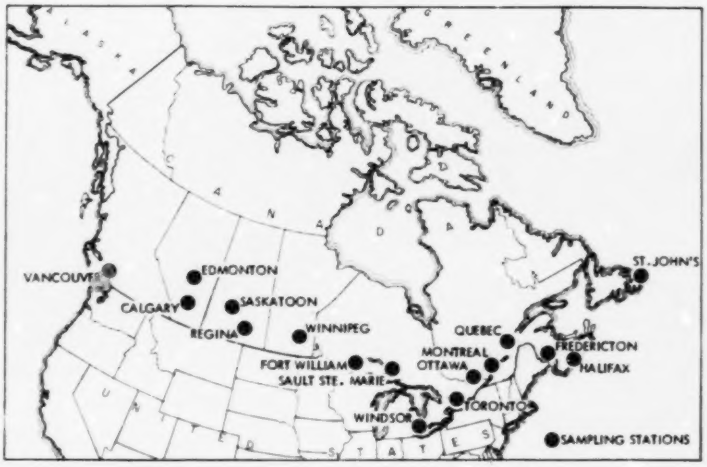

Figure 3. Canadian milk sampling stations

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[1] Prepared from December 1967 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine-131, and monthly composites are analyzed for strontium-90, cesium-137, and stable calcium and potassium. The analytical procedures were outlined in the December 1966 issue of *Radiological Health Data and Reports* (4).

The November 1967 monthly average strontium-90, cesium-137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 5. Iodine-131 and strontium-89 concentrations were below minimum detectable levels.

Table 5. Stable elements and radionuclides in Canadian whole milk, November 1967

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.21	1.5	10	16
Edmonton	1.14	1.6	8	18
Ft. William	1.08	1.5	13	25
Fredericton	1.04	1.5	13	23
Halifax	1.16	1.5	14	21
Montreal	1.06	1.5	11	20
Ottawa	1.12	1.5	8	19
Quebec	1.09	1.5	13	28
Regina	1.13	1.5	8	18
St. John's, Nfld	1.10	1.5	17	31
Saskatoon	1.13	1.5	9	12
Sault Ste. Marie	1.07	1.6	13	29
Toronto	1.10	1.5	5	16
Vancouver	1.24	1.6	16	41
Windsor	1.18	1.5	5	13
Winnipeg	1.11	1.6	7	27
Average	1.12	1.5	11	22

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3. Pan American Milk Sampling Program November 1967

Pan American Health Organization and *U.S. Public Health Service*

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American republics in developing national radiological health programs.

Under a joint agreement between agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (5).

Table 6 presents stable potassium, strontium-90 and cesium-137 monthly concentrations for November 1967.

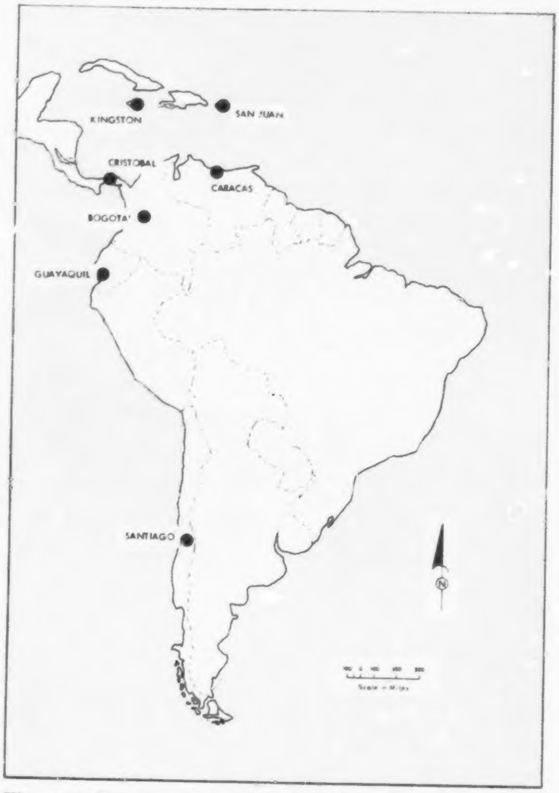

Figure 4. Pan American Milk Sampling Program stations

Table 6. Stable element and radionuclide concentrations in PAHO milk[a], November 1967

Sampling Stations		Number of samples	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Chile:	Santiago	1	1.6	<1	10
Colombia:	Bogota	1	1.5	2	10
Ecuador:	Guayaquil	1	1.6	<1	10
Jamaica:	Mandeville	1	1.6	7	140
Venezuela:	Caracas	0			
Canal Zone:	Cristobal[b]	4	1.5	4	14
Puerto Rico:	San Juan[b]	4	1.6	5	13

[a] Strontium-89 was less than 5 pCi/liter and iodine-131 and barium-140 were less than 10 pCi/liter for all samples.

[b] For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone, and San Juan, Puerto Rico, from the Pasteurized Milk Network are presented.

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(3) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1960).

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State Milk Surveillance Activities

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States now have comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

Figure 1 shows the States which report milk surveillance activities in *Radiological Health Data and Reports*. States having programs appearing in this issue are highlighted in the figure. Following is a summary of previously covered State programs, their reporting period, and the last issue in which they appeared.

State milk network	Period reported	Last presented
Colorado	July–September 1967	January 1968
Connecticut	July–September 1967	February 1968
Florida	July–September 1967	January 1968
Indiana	July–September 1967	February 1968
Iowa	July–September 1967	February 1968
Michigan	July–September 1967	February 1968
Minnesota	July–September 1967	February 1968
New York	April–June 1967	November 1967
Oklahoma	July–September 1967	January 1968
Pennsylvania	July–September 1967	February 1968
Tennessee	July–September 1967	January 1968
Texas	July–September 1967	January 1968

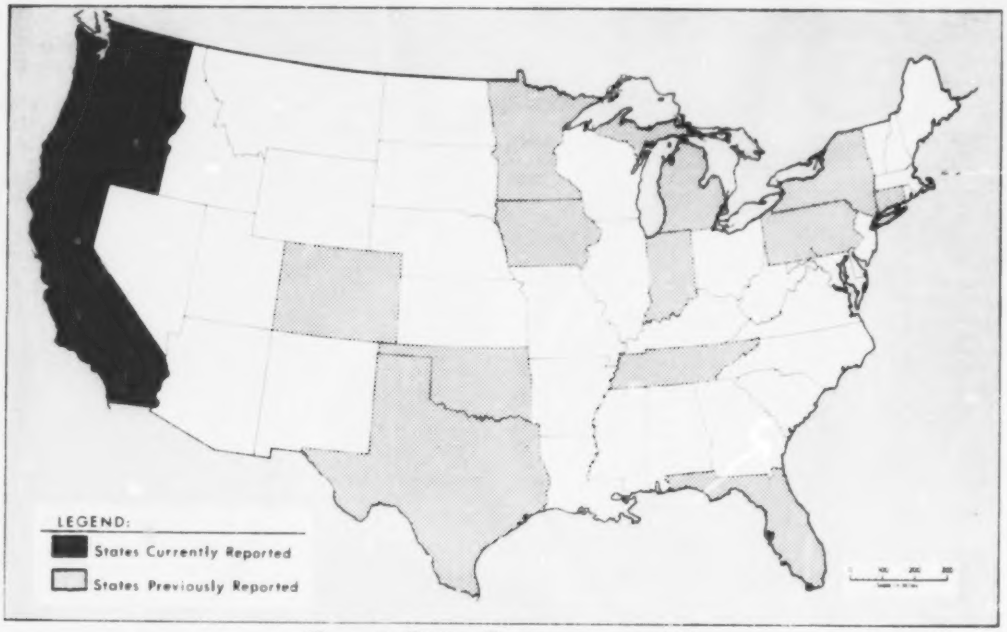

Figure 1. State milk programs reported

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1. California Milk Network
July–September 1967

Division of Environmental Sanitation
State of California, Department of Public Health

Surveillance of specific radionuclides in milk is one phase of the California Department of Health program on radiation control. This milk monitoring function is conducted by the Department's Bureau of Radiological Health at 10 major milksheds (figure 2).

In January 1960, the eight original sampling locations were chosen by the State Department of Agriculture so as to be representative of milk consumed by a high percentage of the State's population. The Del Norte and Mendocino milksheds were added to the program in March 1962 and since that time, weekly, biweekly or monthly sampling of pasteurized milk has been conducted in 10 milkshed areas of the State. A description of the various California milksheds was presented earlier by Heslep and Cornish (*1*).

Strontium–89 and strontium–90 concentrations are determined radiochemically. Potassium–40, iodine–131, cesium–137, and barium–140 in whole fluid milk are determined by gamma-ray scintillation spectrometry. A detailed description of the analytical procedures was presented in an earlier report (*2*).

The monthly calcium and radionuclide concentrations in California pasteurized milk are given in table 1 for the period of July to September 1967. Iodine–131 concentrations for this period were below detectable levels and are not reported in table 1.

Network average strontium–90 and cesium–137 concentrations are presented graphically in figure 3.

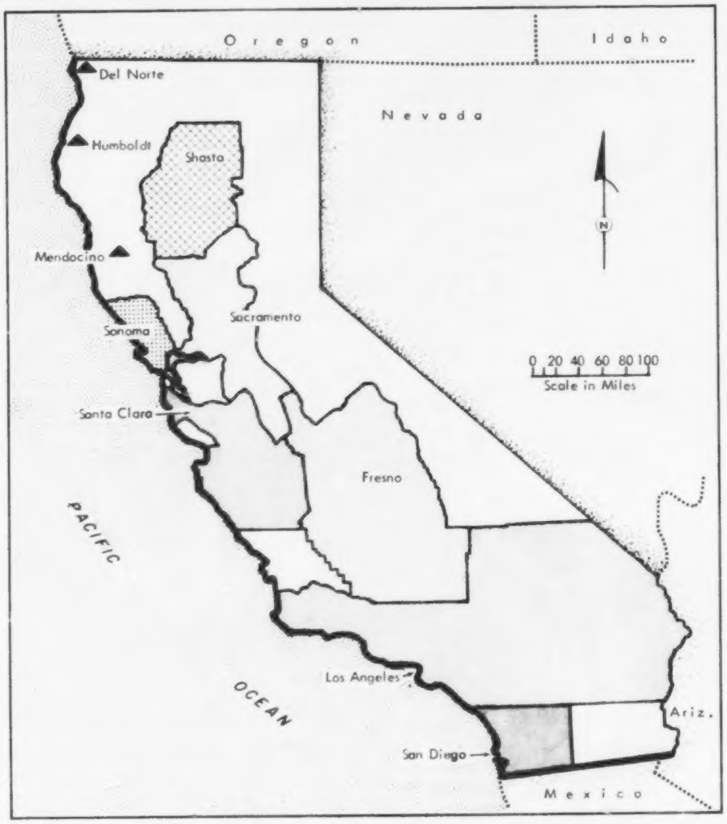

Figure 2. California milksheds

Table 1. Stable elements and radionuclides in California milk, July–September 1967

Sampling location	Calcium (g/liter)			Potassium-40 (pCi/liter)			Strontium-89 (pCi/liter)			Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)			Barium-140 (pCi/liter)		
	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept
Del Norte	NS	NS	1.10	NS	NS	1,200	NS	NS	8	NS	NS	16	NS	NS	8	NS	NS	7
Fresno	1.10	0.95	1.24	1,230	1,350	1,240	[a]2	ND	3	[a]1	1	ND	11	[a]3	[a]7	[a]14	ND	15
Humboldt	1.33	1.29	1.17	1,110	1,090	1,120	ND	ND	ND	5	5	3	9	10	10	[a]11	26	[a]12
Los Angeles	1.11	1.05	1.08	1,280	1,310	1,350	[a]1	ND	ND	1	2	2	[a]4	ND	[a]8	15	ND	[a]9
Mendocino	1.20	1.19	1.13	1,190	1,240	1,230	[a]2	[a]1	[a]1	4	3	1	9	10	[a]3	[a]10	22	[a]6
Sacramento	1.20	1.11	1.14	1,240	1,260	1,230	3	ND	[a]1	3	2	1	[a]7	ND	9	[a]8	ND	[a]13
San Diego	1.15	1.13	1.11	1,200	1,230	NA	[a]1	ND	[a]2	1	3	ND	[a]5	ND	21	[a]8	ND	ND
Santa Clara	1.11	1.12	1.09	1,100	1,260	1,350	[a]1	ND	ND	2	2	ND	[a]7	[a]4	[a]5	ND	ND	[a]9
Shasta	1.13	1.07	1.12	1,200	1,280	1,320	[a]2	[a]1	ND	2	3	3	[a]5	13	[a]7	[a]4	ND	ND
Sonoma	1.08	1.02	1.22	1,250	1,210	1,240	[a]2	ND	ND	2	4	2	[a]7	[a]7	[a]6	[a]9	16	[a]11
Average	1.16	1.10	1.14	1,200	1,250	1,240	[b]1	[b]0	[b]2	[b]2	2	3	[b]7	[b]5	[b]9	[b]9	7	[b]8

[a] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant.

[b] Estimate of average, if 10 percent or more of the values averaged are not statistically significant.

NA, no analysis performed.

NS, no sample collected.

ND, nondetectable.

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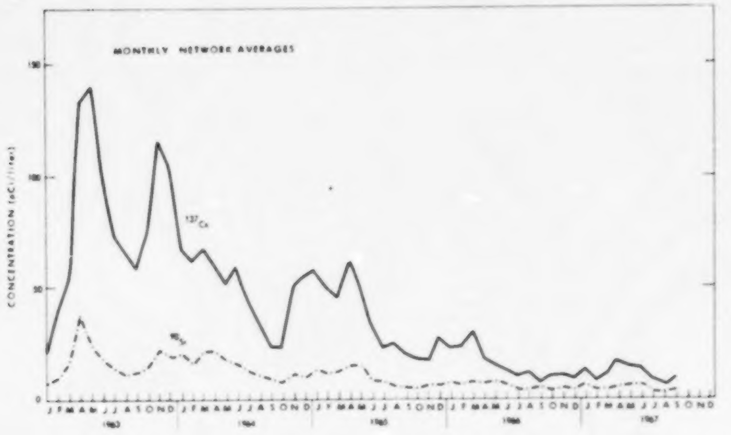

Figure 3. Radionuclide concentrations in California milk 1963–September 1967

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December 1966	June 1967
April–June 1967	December 1967

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2. Oregon Milk Network July–September 1967

Division of Sanitation and Engineering
Oregon State Board of Health

The Oregon State Board of Health has monitored radionuclide concentrations in milk since March 1962. As part of this program routine milk samples are collected at seven major production areas (figure 4), which supply 90 percent of the milk distributed in Oregon. Currently, pasteurized milk samples are collected monthly by the Oregon Department of Agriculture, except in the Portland area where weekly samples are collected by the city of Portland. The milk sampling frequency is accelerated to a weekly basis in areas where iodine-131 concentrations exceed 100 pCi/liter, or when cesium-137 concentrations exceed 500 pCi/liter. Strontium-90 analyses are performed on a bimonthly basis, but may be done monthly when significant increases are observed.

Strontium-90 concentrations are determined using a trichloracetic acid analytical procedure (*3*). Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma-ray scintillation spectrometry (*4*).

Table 2 gives the strontium-90 and cesium-137 concentrations in pasteurized milk from July through September 1967. These data are presented graphically in figure 5. Iodine-131 and barium-140 concentrations remained below minimum detectable levels of 15 pCi/liter for all samples which were collected in July through September 1967.

Table 2. Radionuclide concentrations in Oregon pasteurized milk, July–September 1967

Location	Sampling frequency	Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
		July	Aug	Sept	July	Aug	Sept
Baker	M	5	NS	5	<15	NS	NS
Coos Bay	M	7	NS	8	<15	NS	NS
Eugene	M	4	NS	5	<15	NS	NS
Medford	M	5	NS	5	<15	NS	NS
Portland composite	W	7	7	6	19	20	15
Portland local	W	9	NS	7	24	NS	NS
Redmond	M	6	NS	6	<15	NS	NS
Tillamook	M	23	NS	11	50	NS	NS
Average	------	8	7	7	16	20	15

Key to symbols: M, sampled monthly.
W, sampled weekly.
NS, no sample.

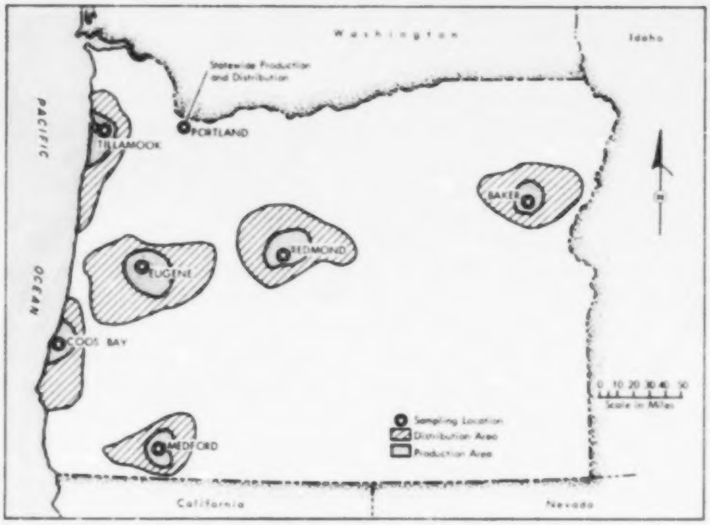

Figure 4. Oregon milk production and distribution areas

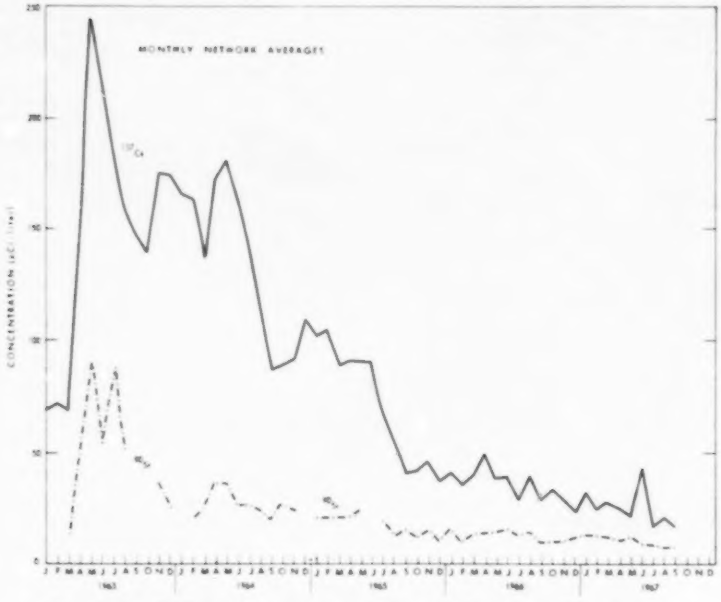

Figure 5. Radionuclide concentrations in Oregon milk network 1963–September 1967

Recent coverage in *Radiological Health Data and Reports*:

Period	*Issue*
January–March 1967	September 1967
April–June 1967	December 1967

3. Washington Milk Network
July–September 1967

Air Quality and Radiation Control Section
State of Washington Department of Health

The Washington State Department of Health initiated a surveillance program for radioactivity in raw milk in December 1962. The collection points shown in figure 6 were selected to provide samples representative of varying climatological conditions within the State's two major milksheds. In addition to the eight milk sampling locations in Washington, milk is sampled from Northwest Idaho (Sandpoint), as this area forms a part of the Spokane milkshed. Details of the sampling procedures were presented in an earlier report (*5*).

Selected samples are radiochemically analyzed for strontium–90. Potassium–40, iodine–131, cesium–137, and barium–140 concentrations are determined by gamma-ray scintillation spectrometry. Details of the analytical procedures were presented earlier (*5*).

Table 3 presents monthly radionuclide concentrations in Washington raw milk for July through September 1967. Samples collected during July through September 1967 contained less than 10 pCi/liter of iodine–131. Barium–140 results remained below 15 pCi/liter for all samples collected during this period. Monthly average strontium–90 and cesium–137 concentrations are presented graphically in figure 7 to display general trends.

During this reporting period, three samples were collected (one from Benton County and

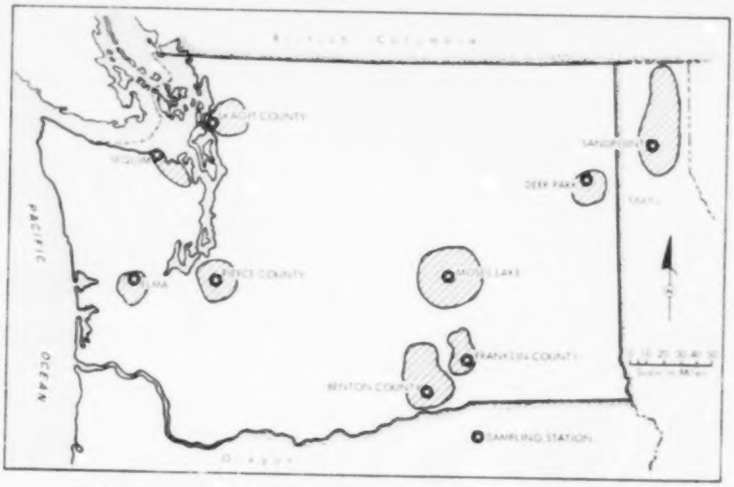

Figure 6. Washington milksheds and sampling locations

Table 3. Radionuclide concentrations in Washington raw milk, July–September 1967

Sampling location	Radionuclide concentrations (pCi/liter)								
	Potassium-40			Strontium-90			Cesium-137		
	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept
Benton County	1,180	NS	1,130	4	NS	2	<15	NS	<15
Deer Park	1,160	1,110	1,190	7	7	3	<15	<15	<15
Elma	1,240	1,230	1,200	8	5	8	27	21	54
Franklin County	NS	1,180	NS	NS	3	NS	NS	<15	NS
Moses Lake	1,290	1,270	1,210	5	4	2	<15	<15	<15
Pierce County	1,110	1,180	1,270	9	6	6	18	<15	17
Sandpoint	1,200	1,270	1,220	13	16	5	28	44	40
Sequim	1,100	1,210	1,210	6	5	3	<15	<15	<15
Skagit County	1,230	1,160	1,260	16	12	7	15	37	23
Average	1,190	1,200	1,210	8	7	5	18	22	24

NS, no sample collected.

two from Franklin County) and analyzed for zinc-65. In all three cases, zinc-65 levels were less than 25 pCi/liter. Milk samples produced in areas using Columbia River water for irrigation have periodically been found to contain this radionuclide.

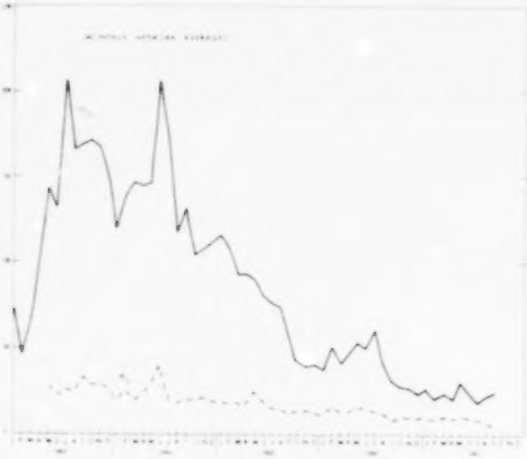

Figure 7. Radionuclide concentrations in Washington milk, 1963–September 1967

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–March 1967	September 1967
April–June 1967	December 1967

REFERENCES

(*1*) HESLEP, J. M. and A. C. CORNISH. California milk network and milkshed comparisons, April–June 1963. Radiol Health Data 4:596–599 (December 1963).

(*2*) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH. California milk network, 1960–June 1962. Radiol Health Data 4:90–92 (February 1963).

(*3*) MURTHY, G. K., J. E. COAKLEY, and J. E. CAMPBELL. A method for the elimination of ashing in strontium-90 determinations in milk. J Diary Sci 43:151–154 (1960).

(*4*) OREGON STATE BOARD OF HEALTH, DIVISION OF SANITATION AND ENGINEERING. Oregon milk network, April–June 1965. Radiol Health Data 6:683–684 (December 1965).

(*5*) STATE OF WASHINGTON DEPARTMENT OF HEALTH, AIR AND RADIATION CONTROL SECTION. Washington milk network, January–June 1965. Radiol Health Data 6:619–621 (November 1965).

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Periodically, results from the United Kingdom Diet Survey, conducted by the United Kingdom Agricultural Research Council Radiobiological Laboratory, are presented for comparison with data observed in the United States. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Last presented
California Diet Study	March–June 1967	February 1968
Connecticut Standard Diet	January–June 1967	November 1967
Institutional Diet, PHS	April–June 1967	January 1968

1. Strontium-90 in Tri-City Diets January–March 1967[1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium-90 content of the average diet of individuals living in New York City, Chicago and San Francisco.

Selected foods representing 19 food categories are purchased at each of these 3 cities every 3 months on a staggered basis (*i.e.*, Chicago, January 1967, New York City, February 1967; and San Francisco, March 1967) and are analyzed for strontium-90. Consumption figures used are based upon data from the Department of Agriculture (*1*). Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general.

The consumption data are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is boned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the waste.

After two samplings at each city, it was found that the calcium content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses of dietary components were performed for the third time recently, and further confirmed this result (*2*). Calcium analyses were therefore discontinued and the average calcium content of foods was computed and used to estimate the average annual intake of this material. Details of the sampling system and a discussion of the results obtained have been summarized (*3*).

Results of the January to March 1967 samplings are presented in table 1. The variation with time of the daily intake of strontium-90

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[1] Data from Fallout Program Quarterly Summary Report, HASL-184. Available from the Clearinghouse for Federal Scientific & Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

Table 1. Average dietary consumption and strontium-90 intake in Tri-City diet January–March 1967

Food category	Diet (kg/yr)	Calcium (g/yr)	Chicago-January 1967		New York-February 1967		San Francisco-March 1967	
			(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)
Milk	221	234.5	6.0	1,326	10.4	2,298	3.5	774
Fresh fruit	68	12.9	7.0	476	14.6	993	7.9	537
Fresh vegetables	43	15.3	17.7	761	9.6	413	4.0	172
Root vegetables	17	6.3	10.4	177	9.3	158	6.9	117
Potatoes	45	4.9	13.6	612	0.9	41	2.3	104
Macaroni	3	0.6	7.4	22	7.4	22	4.6	14
Rice	3	1.0	1.7	5	3.5	11	1.9	6
Fruit juices	19	1.7	4.1	78	7.1	135	5.6	106
Canned vegetables	20	4.2	11.0	220	16.3	326	6.0	120
Canned fruit	26	1.3	2.6	68	3.3	86	1.1	29
Dried beans	3	3.1	21.1	63	16.2	49	1.2	4
Flour	43	8.6	12.4	533	12.0	516	2.9	125
Bakery products	37	39.2	9.4	348	5.3	196	4.9	181
Whole grain products	11	10.1	39.6	436	11.0	121	17.4	191
Fresh fish	8	8.4	4.3	34	0.6	5	0.4	3
Shell fish	1	1.2	0.3	0	1.8	2	1.7	2
Poultry	17	8.2	1.3	22	1.4	24	3.4	58
Meat	73	11.7	0.7	51	1.3	95	1.3	95
Eggs	16	9.3	2.9	46	7.1	114	1.4	22
Annual intake (pCi/yr)	....	382.5	....	5,278	....	5,605	....	2,660
Daily intake (pCi/day)	....	1.1	....	14.4	....	15.4	....	7.3
pCi strontium-90/g Ca	....	....	....	14	....	15	....	7

in the three cities is plotted in figure 1. A discussion of cesium-137 intakes as reflected in the Tri-City Diet Study has been presented previously (4).

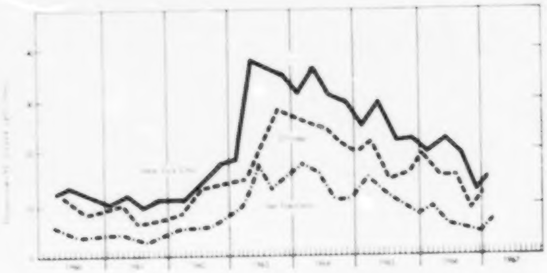

Figure 1. Daily intake of strontium-90 in Tri-City diet, March 1960–March 1967

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
February–April 1966	December 1966
May–July 1966	June 1967
August–December 1966	September 1967

REFERENCES

(*1*) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, household food consumption survey, Report No. 1 (1955). Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (December 1956).

(*2*) U.S. ATOMIC ENERGY COMMISSION. Fallout program quarterly summary report HASL–144:281–287. Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (April 1, 1964); summarized in Radiol Health Data 5:285–288 (June 1964).

(*3*) RIVERA, J., and J. H. HARLEY. HASL contributions to the study of fallout in food chains, HASL–147. Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (July 1, 1964).

(*4*) U.S. ATOMIC ENERGY COMMISSION. Cesium-137 in Tri-City diets, 1965. Radiol Health Data Rep 8:154–157 (March 1967).

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence [1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

Activity	Period reported	Last presented
California Water Sampling Program	July–December 1966	February 1968
Coast Guard Water Sampling Program	January–December 1966	November 1967
Minnesota Municipal Water	January–June 1967	January 1968
New York Surface Water	January–May 1967	January 1968
Radiostrontium in Tap Water, HASL	July–December 1966	November 1967
Washington Surface Water Sampling	July 1965–June 1966	August 1967

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States, September 1967

Division of Pollution Surveillance, Federal
Water Pollution Control Administration
Department of Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha and beta radioanalyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the August 1967 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity concentration is 15 pCi/liter or greater or when the beta radioactivity concentration is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data for comment. They reflect no public health significance as the Public Health Service drinking water standards have already pro-

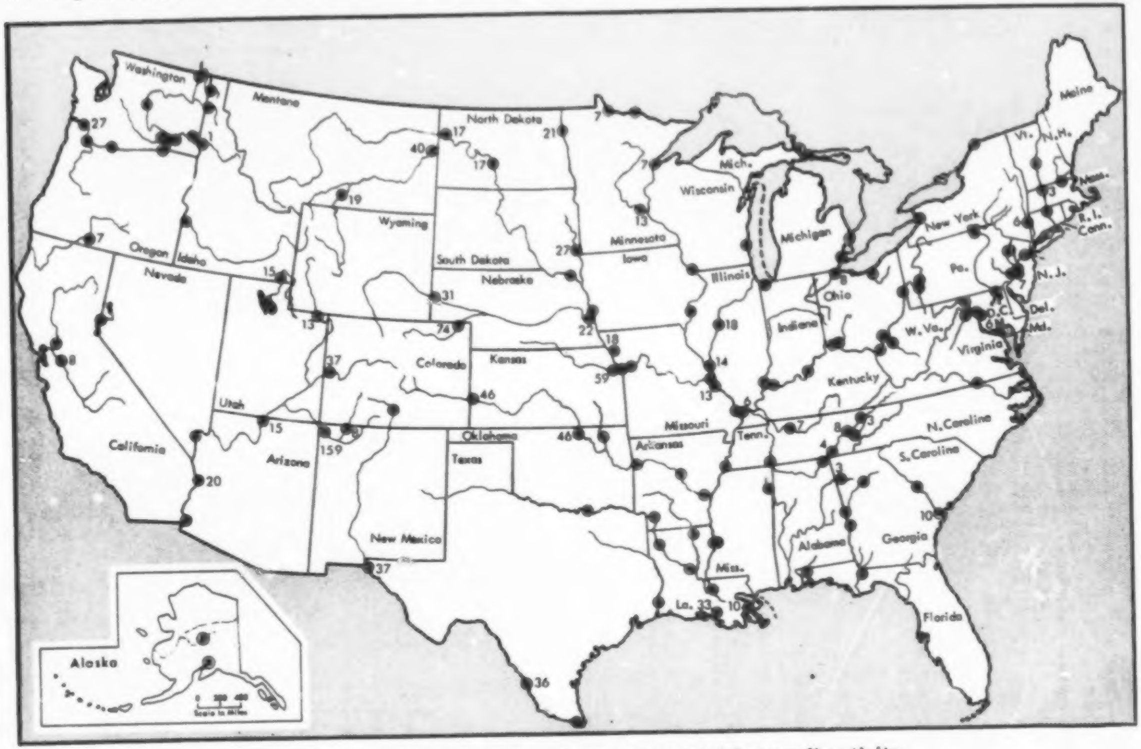

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, September 1967

vided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. A discussion of gross radioactivity per gram of solids for all stations of the Water Pollution Surveillance System for 1961 through 1965 has been presented (*7*). Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During August and September the following stations showed values in excess of 15 pCi/liter on alpha radioactivity for either suspended or dissolved solids:

Arkansas River; Coolidge, Kans.

San Juan River; Shiprock, N. Mex.

South Platte River; Julesburg, Colo.

During September, the following stations showed values in excess of 15 pCi/liter on alpha radioactivity for either suspended or dissolved solids:

Arkansas River; Ponca City, Okla.

Kansas River; DeSoto, Kans.

North Platte River; Henry, Nebr.

Rio Grande; Laredo, Tex.

Yellowstone River; Sidney, Mont.

Table 1. Radioactivity in raw surface waters, September 1967

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	1	3	4	2	6	8
Arkansas River:						
Coolidge, Kans.	10	21	31	26	20	46
Ponca City, Okla.	17	7	24	36	10	46
Atchafalaya River:						
Morgan City, La.	8	1	9	25	8	33
Bear River:						
Preston, Idaho	0	1	1	0	15	15
Big Horn River:						
Hardin, Mont.	4	3	7	8	11	19
Big Sioux River:						
Sioux Falls, S. Dak.	2	6	8	4	23	27
Clearwater River:						
Lewiston, Idaho	0	0	0	0	1	1
Clinch River:						
Clinton, Tenn.	2	2	4	0	3	3
Kingston, Tenn[a]	0	<1	<1	0	8	8
Colorado River:						
Loma, Colo.	4	7	11	21	16	37
Page, Ariz.	1	10	11	<1	15	15
Parker Dam, Calif-Ariz.	0	5	5	0	20	20
Columbia River:						
Clatskanie, Ore.	0	0	0	3	24	27
Connecticut River:						
Northfield, Mass.	0	0	0	0	3	3
Coosa River:						
Rome, Ga.	1	1	2	1	2	3
Cumberland River:						
Cheatham Lock, Tenn.	1	1	2	4	3	7
Delaware River:						
Philadelphia, Pa.	1	2	3	1	6	7
Great Lakes:						
Duluth, Minn.	1	1	2	4	3	7
Green River:						
Dutch John, Utah	<1	5	5	0	13	13
Hudson River:						
Poughkeepsie, N. Y.	2	2	4	0	6	6
Illinois River:						
Peoria, Ill.	2	6	8	4	14	18
Grafton, Ill.	1	7	8	2	12	14
Kansas River:						
DeSoto, Kans.	35	6	41	44	15	59
Klamath River:						
Keno, Ore.	<1	1	1	<1	7	7
Maumee River:						
Toledo, Ohio	1	1	2	1	7	8
Mississippi River:						
St. Paul, Minn.	1	3	4	1	12	13
E. St. Louis, Ill.	1	5	6	1	12	13
New Orleans, La.	0	1	1	0	10	10
Missouri River:						
Williston, N. Dak.	1	1	2	5	12	17
Bismarck, N. Dak.	3	3	11	4	13	17
St. Joseph, Mo.	1	3	4	4	14	18
North Platte River:						
Henry, Nebr.	1	19	20	3	28	31
Ohio River:						
Cairo, Ill.	2	3	5	1	5	6
Platte River:						
Plattsmouth, Nebr	4	5	9	9	13	22
Potomac River:						
Washington, D.C.	1	2	3	1	5	6
Rainy River:						
Baudette, Minn.	<1	1	1	0	7	7
Red River, North:						
Grand Forks, N. Dak.	0	1	1	2	19	21
Rio Grande:						
El Paso, Tex.	13	11	24	22	15	37
Laredo, Tex.	16	4	20	28	8	36
San Joaquin River:						
Vernalis, Calif.	0	1	1	1	7	8
San Juan River:						
Shiprock, N. Mex.	90	7	97	146	13	159
Savannah River:						
Port Wentworth, Ga[a]	1	1	2	2	8	10
South Platte River:						
Julesburg, Colo.	3	48	51	7	67	74
Tennessee River:						
Chattanooga, Tenn.	1	1	2	1	3	4
Yellowstone River:						
Sidney, Mont.	19	7	26	32	8	40
Maximum	90	48	97	146	67	159
Minimum	0	0	0	0	1	1

[a] Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides.

Cedar Hill, N. Mex., on the Animas River decreased to less than 15 pCi/liter on alpha radioactivity concentrations for suspended solids.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*2*) *Ibid.*, 1959 Edition.
(*3*) *Ibid.*, 1960 Edition.
(*4*) *Ibid.*, 1961 Edition.
(*5*) *Ibid.*, 1962 Edition.

In September no station reported a beta radioactivity concentration of more than 150 pCi/liter in either suspended or dissolved solids.

(*6*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(*7*) JULIAN, E. C. Gross radioactivity of the solids in selected surface waters of the United States, 1961–1965. Radiol Health Data Rep 9:1–12 (January 1968).

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radio analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*:

Network	Period	Issue
HASL 80th Meridian Network	Calendar year 1965	January 1967
Plutonium in Airborne Particulates	April–June 1967	November 1967

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1. Radiation Alert Network[1]
November 1967

National Center for Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly samples airborne particulates at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Airborne particulate samples are collected by drawing air through 4-inch diameter MSA No. 2133 'All-Dust" filters at high velocity using either a Staplex "Hi-Volume" sampler or one of several lobar-type positive displacement air pumps. Samples are normally collected on a daily basis for 5 days per week. The sample removed on the morning of the first day of the week usually represents a 48–96 hour sampling period for the previous weekend. Some stations equipped with the "Hi-Volume" sampler use a timing device on weekends that will repetitively turn the sampler on for 1 hour and off for 2 hours, and thus sample for 24 hours over a 72-hour period. In certain circumstances, stations are requested to operate on a daily basis.

At the completion of the sampling period, the filter is removed from the sampler and set aside for approximately 5 hours to permit decay of most of the radon daughter radioactivity that may have been collected. A field estimate of the gross beta radioactivity content is then made using a survey meter equipped with a GM probe. By comparing the result obtained from the filter with that obtained from a strontium-yttrium-90 standard of known radioactivity, the field estimate is calculated as follows:

$$\frac{\text{Net sample reading (cpm)}}{\text{Net standard reading (cpm)}} \times \frac{\text{standard radioactivity (pCi)}}{\text{sample volume (m}^3\text{)}} = \text{field estimate (pCi/m}^3\text{)}$$

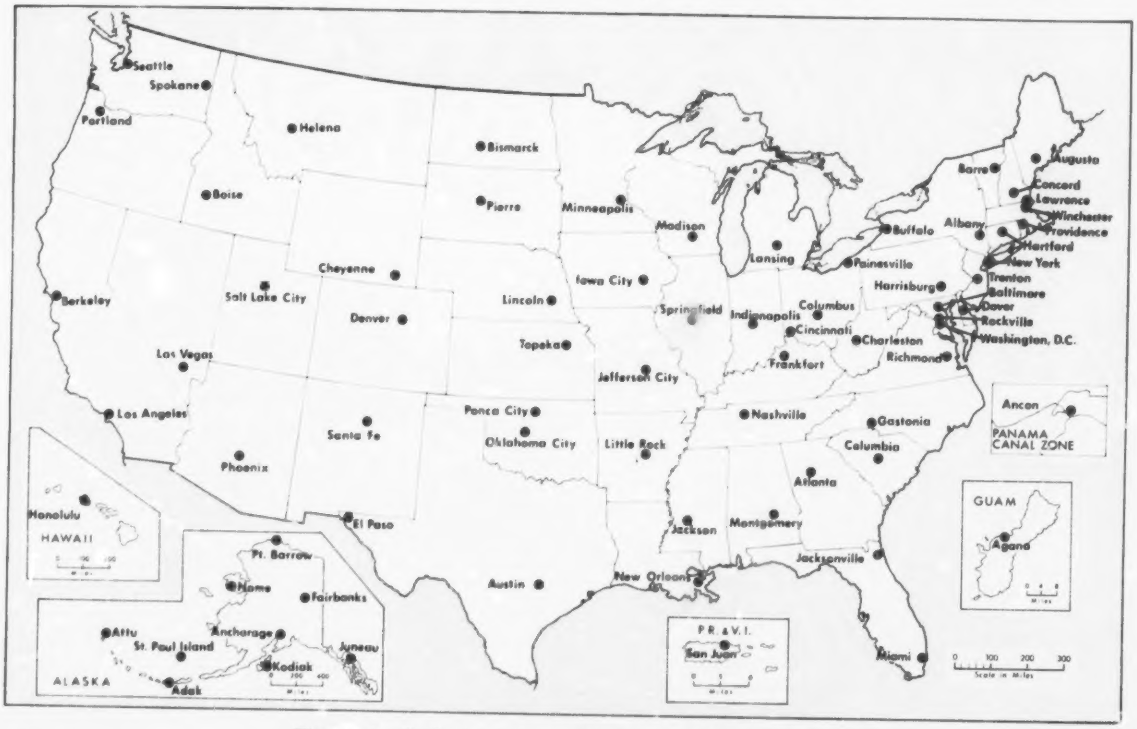

Figure 1 Radiation Alert Network sampling stations

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[1] The name of the Radiation Surveillance Network (RSN) was changed to Radiation Alert Network (RAN) effective November 1, 1967.

A second field estimate of the radioactivity concentration is made approximately 24 hours after the first estimate (29 hours after sample collection) at which time most of the thoron-daughter radioactivity will have decayed.

Continuous sampling of precipitation is done concurrently with air sampling at most RAN stations using funnels with a collection area of 0.4 square meters. The collected liquid, or an aliquot thereof, is evaporated to dryness and a field estimate is made of the gross beta radioactivity deposition in essentially the same manner as for an air sample. The gross beta radioactivity deposition field estimate is calculated as follows:

1. $$\frac{\text{Net sample reading (cpm)}}{\text{Net standard reading (cpm)}} \times \frac{\text{standard radioactivity (pCi)}}{\text{aliquot volume (ml)}} = \text{concentration (pCi/ml or nCi/liter)}$$

2. $$\frac{\text{Total volume of precipitation collected (liters)}}{\text{Collector area } (m^2)} = \text{depth of precipitation (mm)}$$

3. Concentration (nCi/liter) × depth of precipitation (mm) = deposition (nCi/m^2)

Table 1. Gross beta radioactivity in surface air and precipitation, November 1967

Station location		Number of samples		Air surveillance gross beta radioactivity (pCi/m^3)			Last profile in *RHD&R*	Precipitation	
		Air	Pptn	Maximum	Minimum	Average[a]		Total depth (mm)	Total deposition (nCi/m^2)
Ala:	Montgomery	30	4	6.61	.19	2.57	Nov 67	90	[e]10
Alaska:	Adak	30	--------	.36	.36	.36	June 67	--------	--------
	Anchorage	14	1	.00	.00	.00	Dec 67	10	0
	Attu Island	6	--------	.81	.00	.14	July 67	--------	--------
	Fairbanks	(b)	--------	--------	--------	--------	Jan 68	--------	--------
	Juneau	12	9	.00	.00	.00	Feb 68	176	0
	Kodiak	20	--------	.70	.00	.13	Mar 68	--------	--------
	Nome	30	--------	.68	.21	.34	Sept 67	--------	--------
	Pt. Barrow	30	--------	.64	.59	.61	Aug 67	--------	--------
	St. Paul Island	30	--------	1.33	.43	.54	Oct 67	--------	--------
Ariz:	Phoenix	21	6	18.97	1.44	6.50	Feb 68	47	--------
Ark:	Little Rock	17	3	2.25	.20	.72	Dec 67	24	0
Calif:	Berkeley	21	4	3.84	.00	1.15	Mar 68	167	0
	Los Angeles	21	--------	2.21	.24	.92	Sept 67	--------	--------
Colo:	Denver	20	--------	8.10	.13	2.83	Mar 68	--------	--------
Conn:	Hartford	19	9	.42	.12	.24	Jan 68	74	[c]<8
Del:	Dover	20	--------	1.44	.14	.43	Nov 67	--------	--------
D. C:	Washington	27	5	2.20	.22	.74	Aug 67	35	<8
Fla:	Jacksonville	19	1	.99	.24	.41	Dec 67	8	<2
	Miami	18	6	.26	.06	.17	Jan 68	49	0
Ga:	Atlanta	19	7	3.43	.37	.96	Oct 67	194	[e]123
Guam:	Agana	(b)	--------	--------	--------	--------	Nov 67	--------	--------
Hawaii:	Honolulu	30	3	.83	.30	.43	July 67	[d]52	(d)
Idaho:	Boise	20	3	6.04	.95	2.68	July 67	19	0
Ill:	Springfield	18	5	3.81	.16	.88	Aug 67	39	--------
Ind:	Indianapolis	18	9	1.39	.65	.86	Oct 67	51	[e]<41
Iowa:	Iowa City	15	2	2.92	.97	1.71	Mar 68	37	<7
Kans:	Topeka	19	3	3.44	.34	1.07	Dec 67	22	<4
Ky:	Frankfort	15	7	1.97	.69	1.14	Aug 67	52	[e]117
La:	New Orleans	20	2	1.10	.11	.38	Aug 67	[d]19	(d)
Maine:	Augusta	20	6	1.27	.09	.41	Feb 68	91	<3
Md:	Baltimore	21	4	2.38	.31	.69	Jan 68	22	[e]16
	Rockville	13	[f]1	.74	.11	.28	July 67	[d]117	(d)
Mass:	Lawrence	18	6	1.37	.00	.24	Nov 67	80	<1
	Winchester	19	9	2.75	.00	.18	June 67	64	<1
Mich:	Lansing	20	7	2.31	.14	.84	July 67	56	[e]<32
Minn:	Minneapolis	20	--------	.59	.19	.26	Nov 67	--------	--------
Miss:	Jackson	17	1	1.86	.21	.76	Feb 68	6	<1
Mo:	Jefferson City	20	5	2.02	.18	.57	Oct 67	40	<3
Mont:	Helena	21	4	4.32	.24	1.27	June 67	10	[e]<5
Nebr:	Lincoln	20	2	4.13	.99	2.13	Oct 67	12	<2
Nev:	Las Vegas	15	--------	3.47	.17	1.42	Jan 68	--------	--------
N. H:	Concord	19	--------	1.94	.00	.47	Aug 67	--------	--------
N. J:	Trenton	18	3	.51	.12	[illegible]	Feb 68	8	[e]8
N. Mex:	Santa Fe	17	1	1.96	.06	.82	June 67	3	[e]3
N. Y:	Albany	18	8	.78	.11	.48	Oct 67	[illegible]	[e]<79
	Buffalo	2	--------	.32	.19	.25	Mar 68	--------	--------
	New York	20	--------	.42	.16	.19	June 67	--------	--------
N. C:	Gastonia	16	3	[illegible]	.36	5.06	Mar 68	[d]32	(d)
N. Dak:	Bismarck	21	1	3.86	.25	1.64	Aug 67	1	--------
Ohio:	Cincinnati	18	--------	2.81	.40	1.17	Nov 67	--------	--------
	Columbus	17	2	1.33	.14	.45	Feb 68	17	0
	Painesville	21	8	1.87	.11	.46	Jan 68	115	[e]<18

See footnotes at end of table.

Table 1. Gross beta radioactivity in surface air and precipitation, November 1967—Continued

Station location		Number of samples		Air surveillance gross beta radioactivity (pCi/m³)			Last profile in *RHD&R*	Precipitation	
		Air	Pptn	Maximum	Minimum	Average[a]		Total depth (mm)	Total deposition (nCi/m²)
Okla:	Oklahoma City	18	-----	6.09	.00	1.12	July 67	-----	-----
	Ponca City	21	2	7.95	.16	1.34	Jan 68	5	<1
Ore:	Portland	17	8	1.13	.00	.35	Oct 67	60	-----
Pa:	Harrisburg	17	-----	1.68	.32	.77	Oct 67	-----	-----
P. R:	San Juan	(b)	-----	-----	-----	-----	Feb 68	-----	-----
R. I:	Providence	21	9	.55	.00	.15	July 67	64	<1
S. C:	Columbia	9	4	1.42	.00	.54	June 67	86	<2
S. Dak:	Pierre	10	-----	8.52	1.21	3.52	Feb 68	-----	-----
Tenn:	Nashville	11	6	1.30	.30	.70	July 67	67	0
Tex:	Austin	18	2	7.27	.18	2.08	Nov 67	[d]61	(d)
	El Paso	27	2	9.64	1.01	2.79	Aug 67	8	0
Utah:	Salt Lake City	30	1	1.65	.25	.92	Sept 67	11	-----
Vt:	Barre	21	9	1.64	.12	.43	Dec 67	34	<2
Va:	Richmond	14	4	.99	.41	.76	Dec 67	33	<3
Wash:	Seattle	(b)	12	-----	-----	-----	Dec 67	[d]45	(d)
	Spokane	20	1	3.24	.44	1.03	Nov 67	7	-----
W. Va:	Charleston	19	12	1.76	.22	.72	June 67	108	[e]<84
Wis:	Madison	19	4	1.74	.14	.56	Dec 67	49	[e]<10
Wyo:	Cheyenne	21	2	4.20	.35	1.49	Jan 68	5	[e]3
Network summary		1,303	55	18.97	0.00	1.00	-----	49	[e]<12

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] Indicates no report received. (Air samples submitted without field estimate data are not considered by the data program.)
[c] The "<" before deposition value indicates that the calculation used some laboratory findings below the minimum reporting level of concentration of 200 pCi/liter.
[d] This station is part of the plutonium in precipitation net. Gross beta analysis is not done.
[e] Field estimate included.
[f] Sample collected for whole month.

Certain selected stations submit "whole-catch" liquid samples to RAN headquarters where they are composited and sent to NCRH laboratories for selected isotope analysis. These stations do not make field estimates on precipitation.

The samples and field estimate data are mailed to RAN headquarters in Rockville, Md., where compilations of data are made by automatic data processing techniques. Those samples showing abnormal radioactivity levels are forwarded to a NCRH laboratory for further detailed analysis.

The alerting function of the RAN is accomplished by having station operators report unusual findings by telephone to the RAN headquarters as soon as the readings are taken. Appropriate personnel within NCRH, other Federal agencies, and State agencies are advised of any unusual findings. Alert telephone reports are made by station operators for the following conditions:

1. the first (5 hour) field estimate on an air sample exceeds 15 pCi/m³ (7.5 pCi/m³ in Alaska, Hawaii, and Puerto Rico); or
2. the second (29 hour) field estimate on an air sample exceeds 5 pCi/m³; or
3. the field estimate on a dried precipitation sample exceeds 5 nCi/m².

Table 1 presents the monthly average gross beta radioactivity concentrations in surface air particulates (first field estimate) and total gross beta radioactivity deposition by precipitation, as measured by the field estimate technique during November 1967. Time profiles of gross beta radioactivity in air for eight RAN stations are shown in figure 2.

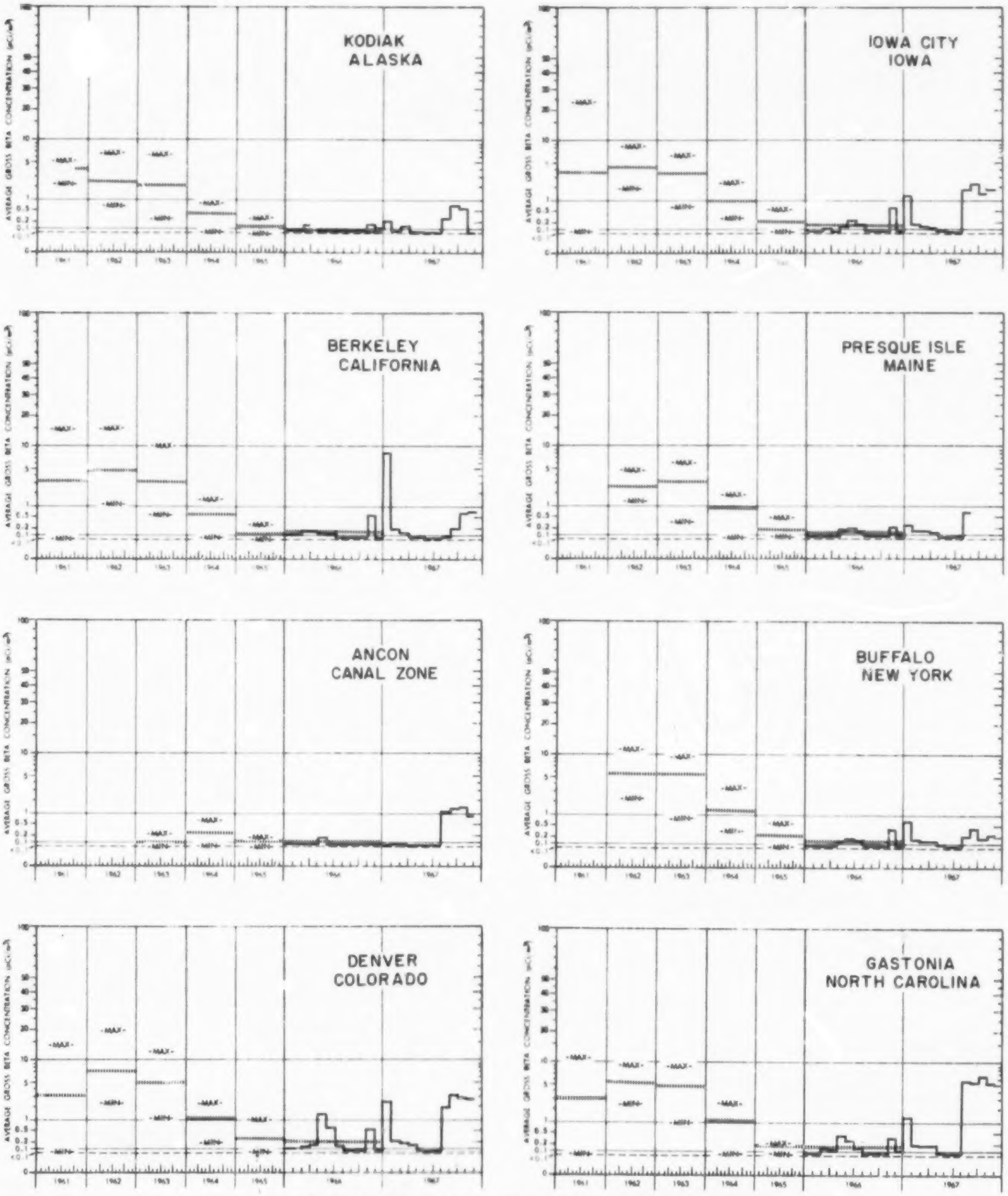

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1961-November 1967

2. Canadian Air and Precipitation Monitoring Program, November 1967

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the November 1966 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for November 1967 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, November 1967

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m²)
Calgary	30	0.3	0.0	0.0	NS	NS
Coral Harbour	28	.2	.0	.0	63	0.9
Edmonton	30	.2	.0	.0	32	.8
Ft. Churchill	30	.1	.0	.0	2	.1
Ft. William	30	.3	.0	.0	17	.3
Fredericton	—	—	—	—	13	1.5
Goose Bay	30	.2	.0	.0	14	.9
Halifax	30	.2	.0	.0	9	1.7
Inuvik	30	.0	.0	.0	3	.1
Montreal	30	.1	.0	.0	13	1.1
Moosonee	30	.0	.0	.0	7	.3
Ottawa	30	.4	.0	.0	11	1.0
Quebec	30	.1	.0	.0	14	1.4
Regina	28	.3	.0	.0	7	.2
Resolute	28	.1	.0	.0	NS	NS
St. John's, Nfld	30	.4	.0	.0	7	.9
Saskatoon	30	.2	.0	.0	14	.2
Saulte Ste Marie	29	.4	.0	.1	16	.9
Toronto	30	.8	.0	.0	7	.3
Vancouver	30	1.5	.0	.1	12	1.4
Whitehorse	30	.7	.0	.0	10	.2
Windsor	30	.1	.0	.0	7	.5
Winnipeg	30	.4	.0	.0	22	.3
Yellowknife	30	.0	.0	.0	13	.3
Network summary	683	1.5	0.0	0.0	14	0.7

NS, no sample.

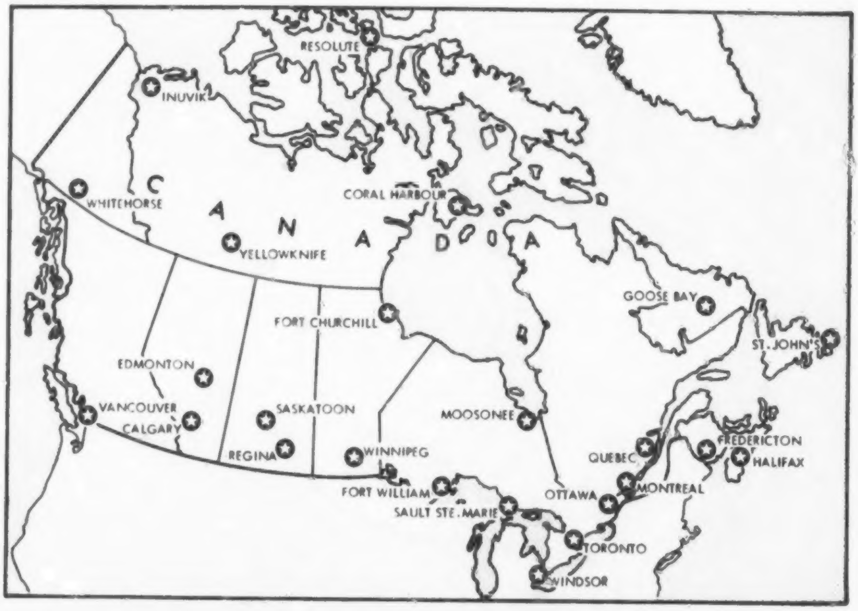

Figure 3. Canadian air and precipitation sampling stations

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[1] Prepared from information and data in the December 1967 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Mexican Air Monitoring Program November 1967

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D. F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D. F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D. F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D. F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month were needed to get a reliable average radioactivity at each station (6).

The maximum, minimum, and average beta radioactivity in surface air during November 1967 are presented in table 3.

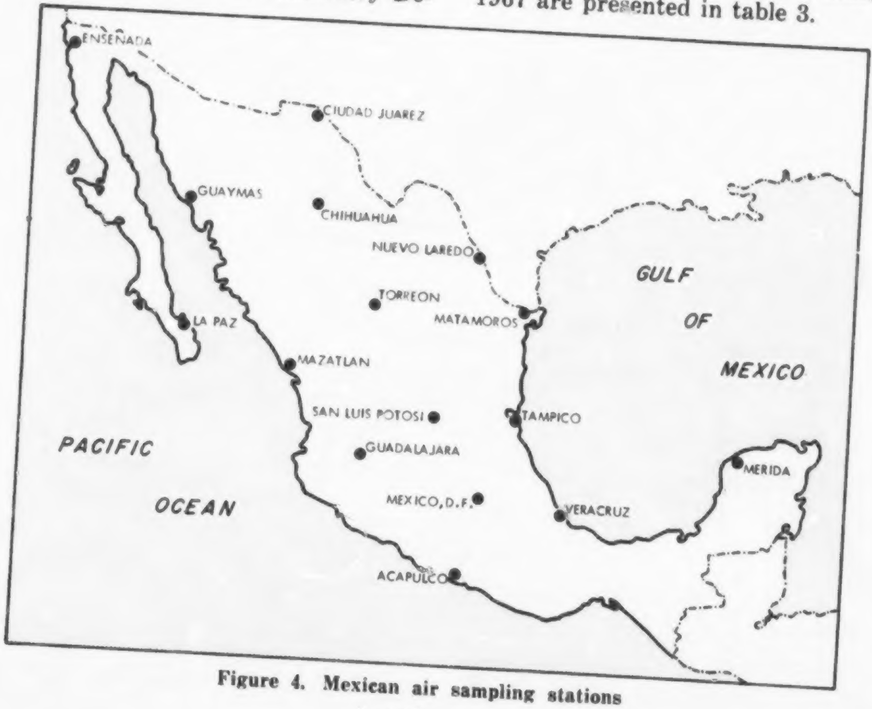

Figure 4. Mexican air sampling stations

Table 3. Mexican gross beta radioactivity of airborne particulates November 1967

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	16	0.3	0.1	0.1
Chihuahua	12	.4	.1	.2
Ciudad Juárez	15	.3	.1	.1
Ensenada	3	.1	.1	.1
Guadalajara	NS			
Guaymas	NS			
La Paz	NS			
Matamoros	NS			
Mazatlan	13	.2	.1	.1
Merida	14	.3	.1	.1
México, D.F.	11	.3	.1	.1
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	13	.1	.1	.1
Torreón	NS			
Veracruz	13	.5	.1	.2

NS, station temporarily shutdown.

4. Pan American Air Sampling Program November 1967

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

Beginning with the present reporting period, sampling equipment and analytical services are being provided by the Southeastern Radiological Health Laboratory (SERHL), PHS, and are similar to those employed for the Radiation Surveillance Network before July 31, 1967. The air sampling station locations are shown in figure 5.

The gross beta radioactivity is determined by cutting a 2-inch diameter disk from each sample which is then counted in a thinwindow, gas-flow, anticoincidence G-M counter. The detector is calibrated with a strontium-90-yttrium-90 standard. The limit of detectability for a typical 24-hour sample is 0.001 pCi/m³.

The November 1967 air monitoring results from the participating countries are given in table 4.

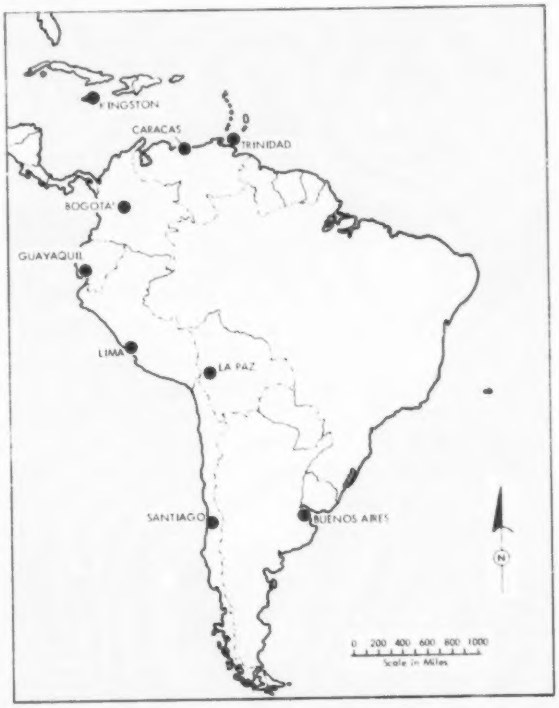

Figure 5. Pan American Air Sampling Program stations

Table 4. Gross beta radioactivity in surface air, PAHO November 1967

Station location	Number of samples	Gross beta radioactivity (pCi/m^3)		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	13	0.11	0.04	0.07
Bolivia: La Paz	20	.04	.01	.02
Chili: Santiago	30	.07	.02	.04
Colombia: Bogota	20	.01	.00	.01
Ecuador: Guayaquil	28	.07	.02	.04
Jamaica: Kingston	22	.05	.01	.02
Peru: Lima	16	.08	.04	.05
Venezuela: Caracas	19	.02	.00	.00
West Indies: Trinidad	18	.03	.00	.01
Pan American summary	186	0.11	0.00	0.03

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of less than 0.005 pCi/m^3 are reported and used in averaging as 0.00 pCi/m^3.

5. Fallout in the United States and Other Areas, January–June 1967[1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

Monthly fallout deposition rates for strontium–90 are determined by the Health and Safety Laboratory (HASL) for 49 sites in the United States and 107 locations in other countries. HASL data from all of the active United States stations and other selected points in the Western Hemisphere (figure 6) covering the period from January through June 1967, are summarized in tables 5 and 6. All the stations of the 80th Meridian Network are represented.

Methods of collection

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout are collected for a period of 1 month in a stainless-steel pot with an exposed area of 0.076 m^2. At the end of the collection period, the contents are transferred, by careful scrubbing with a rubber spatula, to a polyethylene sample bottle which is then shipped to the laboratory for analysis.

The second method involves the use of a polyethylene funnel, with an exposed area of 0.072 m^2, attached to an ion exchange column. After a 1-month collection, the inside of the funnel is wiped with a tissue, and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis. It has been shown that at the 95-percent confidence level there was no significant difference in the strontium–90 measurements obtained from samples collected by the two methods (*1*).

Laboratories at Westwood, N. J., New York City, N. Y., and Seattle, Wash., have analyzed monthly precipitation samples for other radionuclides. The amount of precipitation at each station and the monthly deposition rates for iron–55, strontium–90, cerium–144, plutonium–238, and plutonium–239 -240, at each station are presented in table 7.

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[1] The data in this article were taken from "Fallout Program Quarterly Summary Report," HASL 184:A-4 to A-170; B-1 to B-22.

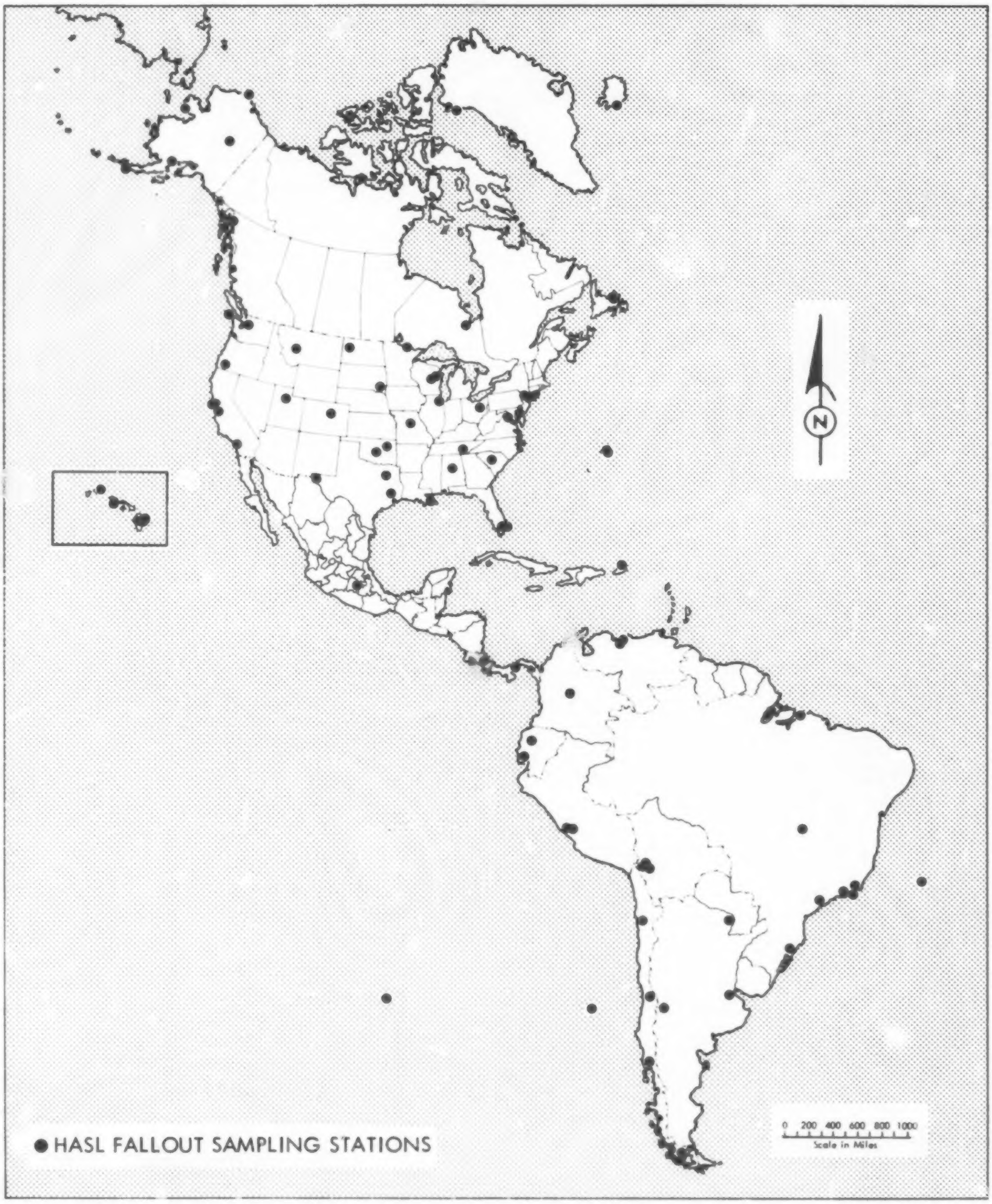

Figure 6. HASL fallout sampling stations in the Western Hemisphere

Table 5. Strontium-90 fallout in the United States, HASL, January–June 1967

Sampling location		Type of collection	Deposition (nCi/m²)					
			Jan	Feb	Mar	Apr	May	June
Ala:	Birmingham	pot	0.09	0.16	0.08	0.13	0.16	0.10
Alaska:	Anchorage	column	.02	.03	.04	.04	.07	.08
	Barrow	column	.01	.01	.02	.01	.01	.02
	Cold Bay	column	.07	.09	.04	NS	.14	.16
	Fairbanks	column	.02	.01	.02	.01	.05	.07
	Juneau	column	.21	.03	.05	.10	.03	NS
	Nome	column	NS	NS	NS	NS	.04	.02
Calif:	W. Los Angeles	pot	.15	.03	.13	.16	.02	.01
	San Francisco	column	.22	.02	.16	.14	.02	.04
Colo:	Denver	column	.05	.09	.02	.18	.24	.16
Fla:	Coral Gables	pot	.05	.03	.16	.01	.09	NS
	Miami	column	.07	.03	.09	.04	.04	.13
Hawaii:	Hilo	column	.28	.34	.31	.53	.20	.19
	Honolulu	pot	.03	.49	.14	.13	.27	.12
	Lihue	column	.17	.12	.13	.15	.08	.05
	Mauna Loa	column	.03	.01	.06	.05	.04	.01
Ill:	Argonne	pot	.06	.05	.28	.21	.12	.13
La:	New Orleans	column	.06	.06	.07	.04	.10	.05
Minn:	International Falls	column	.04	.02	.08	.18	.05	.15
Mo:	Columbia	column	.05	.04	.19	.21	.13	.11
Mont:	Helena	column	.02	.06	.06	.09	.04	.18
N.J.:	Westwood	pot	.12	.06	NS	NS	NS	NS
N.Y:	New York City	pot	.16	.11	.17	.24	.31	.13
N. Dak:	Williston	column	.02	.01	.04	.14	.02	.12
Ohio:	Wooster	pot	.04	.04	.09	.01	.01	.22
Okla:	Tulsa	pot	.04	.07	.11	.17	.25	.13
Ore:	Medford	column	.09	.07	.06	.08	.09	.05
S.C:	Columbia	column	.11	.14	.08	.15	.20	.09
S. Dak:	Vermillion	pot	.06	.02	.07	.06	.25	.41
Tex:	Dallas	column	.02	.07	.08	.14	.19	.10
	El Paso	column	.01	.02	.03	.02	.02	.03
	Houston	column	.04	.02	.04	.07	.04	.01
Utah:	Salt Lake City	pot	.28	.13	[a].20	[a].20	.22	.28
Va:	Sterling	column	.05	.04	.12	.06	.18	.05
Wash:	Seattle	pot	.11	.13	.18	NS	NS	NS
	Seattle	pot	.20	.07	.16	.10	.06	.07
	Forks	column	NS	NS	.40	.19	.08	.03
Wis:	Green Bay	column	.04	.01	.09	.23	.12	.20

[a] Indicates proportioned from originally consolidated data.
NS, no sample reported.

Table 6. Strontium-90 fallout in North and South America, HASL, January–June 1967

Sampling location		Type of collection	Deposition (nCi/m²)					
			Jan	Feb	Mar	Apr	May	June
Argentina:	Buenos Aires	column	0.13	0.11	0.05	0.05	0.03	0.04
	Formosa	column	.07	.03	.02	.01	.03	.03
	Malargue	column	.02	.01	.03	.01	.01	NS
Bahamas:	Bimini	column	.01	.02	.04	.01	.04	.17
Bermuda:	Kindley AFB	column	.05	.11	.10	.17	.10	.07
Bolivia:	Chacaltaya	column	.02	.02	.02	.01	.01	.01
	La Paz (city)	column	.02	.02	.01	.01	.01	.01
	La Paz (Ovejuyo)	column	.03	.02	.01	.01	.02	.02
Brazil:	Belem	column	.04	.04	.05	NS	NS	.02
	Brasilia	pot	NS	NS	NS	NS	NS	NS
	Itaici Sao Paulo	pot	NS	NS	NS	NS	NS	NS
	Nova Friburgo	pot	.07	.03	.03	.01	NS	NS
	Rio de Janeiro	column	.04	NS	NS	NS	NS	NS
	San Jose Dos Compos	pot	.01	NS	NS	NS	NS	NS
	Sao Leopoldo	pot	.26	.11	.15	.01	NS	NS
	Trindade Island	column	.05	.02	.03	.01	NS	NS
Canada:	Moosonee	column	.01	.01	.05	.08	.05	.07
Canal Zone:	Balboa	column	02	.02	.02	.07	.04	.01
Chile:	Antofagasta	column	.01	NS	NS	NS	NS	NS
	Isla Robinson Crusoe[a]	column	.04	NS	NS	NS	NS	NS
	Easter Island	column	[b].03	[b].03	.02	.04	.02	NS
	Puerto Montt	column	NS	.08	.08	.05	.13	NS
	Punta Arenas	column	.04	.03	.04	.02	.06	NS
	Santiago	pot	.01	.01	.01	.03	.03	.03
	Santiago	column	.01	.01	.02	.01	.07	.04
Colombia:	Bogota	pot	[c]T	.01	NS	NS	NS	NS
Costa Rica:	Turrialba	column	.02	.01	.02	.02	.04	.02
Equador:	Guayaquil	column	NS	.03	.01	.01	.01	NS
	Quito	column	.03	.01	.01	.01	.02	.01
Greenland:	Thule	column	.01	.01	.01	.01	.05	NS
Iceland:	Keflavik	column	.07	.12	.06	.11	.06	NS
Mexico:	Mexico City	column	.02	.01	.01	.03	.05	.03
Peru:	Lima	column	.02	NS	NS	.01	NS	NS
	Lima	column	.02	.44	.01	.01	.01	NS
Puerto Rico:	San Juan	column	.04	.06	.06	.04	.05	.06
Venezuela:	Caracas (site 1)	column	.02	.02	.02	.04	.02	.01
	Caracas (site 2)	column	.01	.01	.02	.02	.02	.03

[a] Isla Alejandro Selkirk.
[b] Indicates proportioned from originally consolidated data.
[c] T, trace or zero.
NS, no sample reported.

Table 7. Radiochemical analyses of precipitation samples at 3 U.S. sites, HASL January–June 1967

	Jan	Feb	Mar	Apr	May	June
Precipitation (cm)						
N. J.: Westwood	4.29	0.48	NS	NS	NS	NS
N. Y.: New York City	3.53	6.81	15.16	8.76	10.36	11.78
Wash.: Seattle	18.72	4.62	7.87	NS	NS	NS
Iron-55 (nCi/m²)[a]						
N. J.: Westwood	1.25	0.66	NS	NS	NS	NS
Wash.: Seattle	1.22	NS	NS	NS	NS	NS
Strontium-90 (nCi/m²)[b]						
N. J.: Westwood	0.12	0.06	NS	NS	NS	NS
N. Y.: New York City	0.16	0.11	0.17	0.24	0.31	0.13
Wash.: Seattle	0.11	0.13	0.18	NS	NS	NS
Cerium-144 (nCi/m²)[b]						
N. J.: Westwood	NS	NS	NS	NS	NS	NS
Wash.: Seattle	0.81	0.64	0.40	NS	NS	NS
Plutonium-238 (nCi/m²)						
N. Y.: New York City	0.00014	0.00020	0.00034	0.00154	0.00091	0.00057
Wash.: Seattle	0.0001	0.0014	0.0011	NS	NS	NS
Plutonium-239-240 (nCi/m²)						
N. Y.: New York City	0.00167	0.00192	0.00199	0.00519	0.00306	0.00129
Wash.: Seattle	0.0006	0.0009	0.0002	NS	NS	NS

[a] Decay corrected to 10/15/61.
[b] Decay corrected to midpoint of sampling month.
NS, no sample reported.

REFERENCES

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(*2*) BIRD, P. M., A H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4, Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J., and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(*6*) VASQUEZ, M., and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la Republica Mexicana, 1963–1965. Comisión Nacional de Energía Nuclear, Dirección General de Seguridad Radiológica (in press 1966).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the AEC Manual.[1]

Summaries of data from the environmental radioactivity monitoring reports follow for the Argonne National Laboratory, Atomics International, Feed Materials Production Center, and the National Reactor Testing Station.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Argonne National Laboratory
January–June 1967[2]

University of Chicago
Lemont, Illinois

The radioactivity of the environment is determined on a continuing basis by measuring the radioactivity in naturally-occurring materials collected both on and off the Argonne National Laboratory site. Since radioactivity is usually spread by air and water, the environmental monitoring program at Argonne has concentrated on these materials. The sampling locations discussed in this report are shown in figures 1 and 2.

Air monitoring

Air-filter samples were collected continuously at seven locations on the Argonne site and at five locations off the site. The alpha and beta radioactivity in air filter samples are summarized in table 1. The alpha radioactivity concentrations were normal both on and off the site and in the range found in previous years. The beta radioactivity was presumed to result from fission and neutron-activation products from nuclear detonations. Fission products following the Chinese nuclear test of December 28, 1966 were present in air and precipitation beginning January 2, 1967. The short-lived fission products from this source decayed with time as expected and had essentially disappeared by the end of June 1967. The December 1966 test contributed about 0.1 pCi/m^3 to the

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[2] Summarized from "Environmental Radioactivity at Argonne National Laboratory, January–June 1967," University of Chicago, Lemont, Ill.

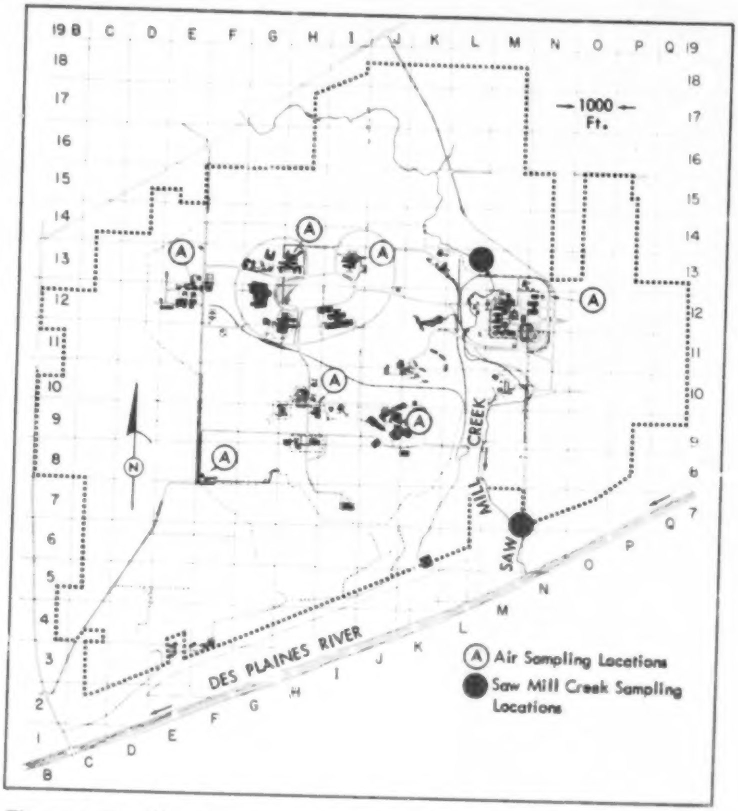

Figure 1. Sampling locations on the site of Argonne National Laboratory

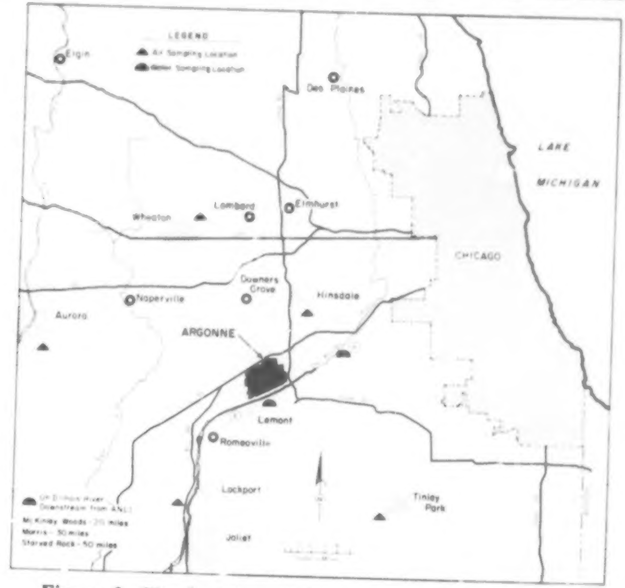

Figure 2. Site location of Argonne National Laboratory (including some offsite sampling stations)

Table 1. Alpha and beta radioactivity in air-filter samples[a] Argonne, January–June 1967

Period	Location	Number of samples	Alpha radioactivity (pCi/m³) multiply by 10^{-3}			Beta radioactivity (pCi/m³)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
January	onsite	26	0.45	0.27	0.60	0.45	0.10	1.14
	offsite	23	.47	.21	.78	.46	.12	1.45
February	onsite	25	.40	.27	.53	.15	.10	0.27
	offsite	20	.39	.25	.54	.15	.09	.26
March	onsite	27	.44	.25	.74	.14	.09	.20
	offsite	22	.43	.27	.84	.15	.11	.23
April	onsite	23	.37	.21	.53	.15	.05	.22
	offsite	20	.50	.28	.77	.18	.03	.33
May	onsite	26	.46	.23	.83	.11	.06	.21
	offsite	23	.53	.33	.87	.12	.09	.21
June	onsite	24	.42	.20	.77	.06	.04	.09
	offsite	22	.42	.30	.76	.06	.03	.11
January-June	onsite	151	0.42	0.20	0.83	0.18	0.04	1.14
	offsite	130	0.46	0.21	0.87	0.19	0.03	1.45

[a] These results were obtained by measuring the samples 4 days after they were collected in order to avoid counting the natural radioactivity due to radon and thoron decay products.

average airborne beta radioactivity of 0.19 pCi/m³ during the first half of 1967. Fallout levels were approximately the same as during 1966. The Chinese nuclear test of June 17, 1967, did not produce a detectable quantity of fallout in the air samples.

Sampling on charcoal for gaseous radioiodine was conducted continuously on the ANL site only. Iodine-131 was present only in trace amounts during the first and second week of January. This radioactivity followed the Chinese nuclear test of December 1966.

Water monitoring

Argonne wastewater is discharged into Sawmill Creek, a stream that runs through the Argonne grounds and enters the Des Plaines River about 500 yards downstream from the wastewater discharge. Sawmill Creek was sampled above and below the discharge to evaluate the effect of the wastewater on the radioactivity in the creek. The sampling locations are shown in figure 2.

Below the wastewater outfall the creek was usually sampled three times weekly. Since it was impractical to analyze all the samples for all the nuclides and elements desired, equal portions of the three samples collected each week were combined and analyzed. The results obtained in this way represent the average concentrations in the weekly samples. Additional samples were collected when unusual amounts of radioactivity were expected or found in the wastewater. Above the site,

Table 2. Non-volatile alpha and beta radioactivity in Sawmill Creek water, Argonne, January–June 1967

Month	Location[a]	Number of samples	Alpha radioactivity (pCi/liter)			Beta radioactivity (pCi/liter)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
January	Upstream	2	3.9	2.6	5.3	21	15	26
	Downstream	9	1.7	1.6	1.9	15	11	20
February	Upstream	2	2.3	1.7	2.8	15	13	18
	Downstream	12	3.1	0.3	4.8	40	30	49
March	Upstream	2	2.1	2.1	2.2	8.7	7.5	9.9
	Downstream	15	2.5	1.7	4.2	21	11	52
April	Upstream	1	----	----	2.3	5.5	3.0	7.9
	Downstream	15	1.7	1.4	1.9	12	9.8	14
May	Upstream	2	1.3	1.0	1.5	6.6	6.3	7.4
	Downstream	12	2.3	.9	4.3	34	12	86
June	Upstream	2	1.5	.9	2.1	9.3	5.9	13
	Downstream	15	1.2	.8	1.4	18	8.7	26
January-June	Upstream	11	2.2	0.9	5.3	11	3.0	26
	Downstream	78	2.1	0.3	4.8	23	8.7	86

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).

samples were collected at weekly intervals, and at least one sample each month was analyzed for each radioactive nuclide of interest. The total alpha and beta radioactivities found in Sawmill Creek during the first half of 1967 are given in table 2.

Upstream from the Argonne site the alpha radioactivity was due primarily to radioactive nuclides that occur naturally in the stream. Any additional radioactivity below the wastewater outfall was due to alpha-emitting nuclides present in the waste water. The concentration of alpha radioactivity in the creek resulting from the presence of Argonne wastewater can be estimated as follows. Below the outfall, the natural creek water was diluted approximately in half by Argonne waste water. Consequently, the average natural alpha radioactivity in the creek below the outfall was approximately one-half of the above-site radioactivity, or about 1.1 pCi/liter, and the average radioactivity due to waste water was about 1.1 pCi/liter. This is the same as the corresponding 1966 average.

The alpha-particle emitters most likely to be present in Argonne waste water are isotopes of uranium, plutonium, and thorium. The alpha radioactivity in the creek water due to these elements are summarized in table 3. Comparison of these concentrations with the total alpha radioactivity indicates that most of the alpha radioactivity added to the creek in Argonne waste water was due to uranium. The uranium concentrations above the site were normal. Below the outfall, the waste water added an average of about 1.2 pCi of uranium per liter of waste water or 0.003 percent of the AEC radiation protection standard. The average plutonium and thorium concentrations above and below the outfall were less than the minimum detectable amount.

Table 3. Alpha-emitting elements in Sawmill Creek water Argonne, January–June 1967

Element	Location[a]	Number of samples	Concentration (pCi/liter)			Average as a percent of AEC standard[b]
			Average	Minimum	Maximum	
Uranium	Upstream	12	1.7	0.8	3.2	0.004
	Downstream	81	2.1	0.8	4.4	0.005
Plutonium	Upstream	6	—	—	<0.05	—
	Downstream	39	<0.05	<0.05	0.10	<0.001
Thorium	Upstream	6	—	—	<0.05	—
	Downstream	39	—	—	<0.05	—

[a] Relative sampling location with respect to Argonne waste water outfall (figure 1).

[b] AEC radiation protection standards—uranium, 4 x 10^4 pCi/liter, plutonium, 5 x 10^3 pCi/liter.

In addition to the natural beta radioactivity in the creek, beta radioactivity from nuclear detonations was detected at both sampling locations and beta radioactivity from Argonne wastewater was found in some samples below the outfall. The natural beta radioactivity concentration is approximately 5 pCi/liter above the site and 3 pCi/liter below the site. The Argonne contribution to the total beta radioactivity below the outfall during the first half of 1967 is estimated to be approximately 15 pCi/liter, compared to 45 pCi/liter in 1966 and 5 pCi/liter in 1965. The remaining radioactivity at both locations, about 5 pCi/liter, was due to fallout. The concentrations of fallout radioactivity was about the same as that found during 1966.

Since Sawmill Creek empties into the Des Plaines River, which in turn flows into the Illinois River, the radioactivity in the latter two streams is important in assessing the contribution of Argonne wastewater to the environmental radioactivity. The Des Plaines River was sampled monthly above the mouth of Sawmill Creek and weekly below, to determine if the radioactivity in the creek had any effect on the radioactivity in the river. The total radioactivity is summarized in table 4. The concentrations were similar at both locations except for two samples, collected in January and February below the mouth of Sawmill Creek, that contained abnormally high concentrations of beta radioactivity (49 and 66 pCi/

Table 4. Average radioactivity in Des Plaines and Illinois River water, Argonne, January–June 1967

Location	Concentration (pCi/liter)		
	Non-volatile alpha radioactivity	Non-volatile beta radioactivity	Uranium
Des Plaines River[a] (above Sawmill Creek)	2.7	17	1.9
Des Plaines River[b] (below Sawmill Creek)	2.6	17	1.9
Illinois River[c]	1.8	11	2.2

[a] Sampled near Route 45, upstream from the mouth of Sawmill Creek.

[b] Sampled near Lemont, downstream from the mouth of Sawmill Creek.

[c] One sample collected at McKinley Woods State Park, on June 8, 1967.

liter). These samples contained the same mixture of fission products found in air. Since they were collected when fallout following the December 1966, Chinese test was at a high level, the excess beta radioactivity is probably due to fallout. Samples were not obtained above the site on the 2 days when high beta radioactivity was found in below-site river water.

The Des Plaines River samples were also analyzed for uranium and the alpha-particle emitting isotopes of plutonium and thorium. All results were normal and similar to those found earlier. The uranium concentrations averaged 1.9 pCi/liter at both locations. Plutonium was not detected at either location and thorium was found in two below-site samples at concentrations of 0.07 and 0.06 pCi/liter, respectively. The detection limit for plutonium and thorium is 0.05 pCi/liter.

The Illinois River was sampled at McKinley Woods on June 8, and the alpha and beta radioactivity concentrations, 1.8 and 11.0 pCi/liter, respectively, were normal and similar to those found in other nearby streams at that time. No radioactivity originating at Argonne was detected in the Des Plaines or Illinois Rivers.

Radioactivity in milk

Raw milk was collected monthly from a local diary farm and analyzed for several fission products. Barium-140, strontium-89, and iodine-131 were not present in concentrations greater than the minimum detectable amounts of 20 pCi/liter for iodine-131 and 3 pCi/liter for the other two radionuclides. The cesium-137 and strontium-90 concentrations are given in table 5. These two nuclides are long-lived fission products from past nuclear tests and their presence in milk is not related to Argonne operations. Concentrations were similiar to those found during the first half of 1966 and no correlation with fallout from the December 1966 test was apparent or expected since the maximum fallout occurred when the cows were on winter feed.

Table 5. Fission product concentrations in milk, Argonne, January-June 1967

Date collected	Concentrations (pCi/liter)	
	Cesium-137	Strontium-90
January 11	70	5.5
February 8	72	9.0
March 2	65	9.2
April 11	87	7.7
May 1	92	9.6
June 21	102	6.6
Average	81	7.9

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January-June 1966	March 1967
July-December and annual summary 1966	September 1967

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2. Atomics International
January-June 1967[3]

North American Aviation, Inc.
Canoga Park, California

Atomics International, a division of North American Aviation, Incorporated, has been engaged in atomic energy research and development since 1946. The company designs, develops, and constructs nuclear reactors for central station and compact power plants and for medical, industrial, and scientific applications.

The company headquarters is located in Canoga Park, Calif., approximately 23 miles northwest of downtown Los Angeles. The 290-acre Nuclear Development Field Laboratory (Santa Susana Facility), equipped with extensive testing facilities for the support of advanced nuclear studies, is in Ventura County in the Simi Hills approximately 29 miles northwest of downtown Los Angeles. The location of the above sites in relation to nearby communities is shown in figure 3.

The basic concept of radiological hazard control at Atomics International encourages total containment of radioactive materials, and through rigid operational controls, minimizes effluent releases and external radiation levels. The environmental monitoring program provides a check on the effectiveness of radiological

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[3] Summarized from "Environmental Monitoring, Semiannual Report, January 1, 1967 to June 30, 1967," Atomics International, Division of North American Aviation, Inc.

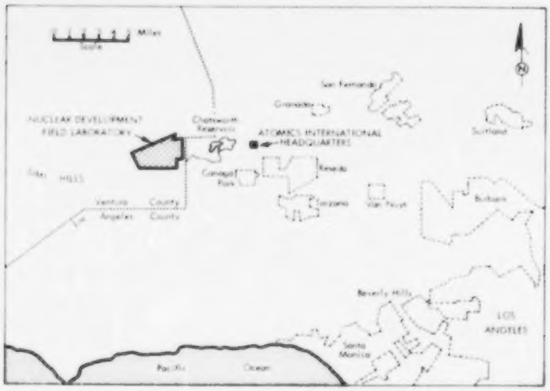

Figure 3. Atomics International facilities and vicinity

safety procedures and of engineering safeguards incorporated into facility design.

The environs of Atomics International headquarters and Nuclear Development Field Laboratory (NDFL) are surveyed monthly to determine the concentration of radioactivity in typical surface soil, vegetation, and water samples. In addition, continuous environmental air monitoring at the sites provides information concerning airborne particulate radioactivity.

Air monitoring

Environmental air sampling is conducted continuously at the headquarters and NDFL sites with automatic air samplers operating on 24-hour sampling cycles. Airborne particulate radioactivity is collected on HV–70 filter paper which is automatically changed at the end of each sampling period. The filter is removed from the sampler and counted after the radioactivity is allowed to decay for at least 72 hours. The volume of a typical daily environmental air sample is approximately 20 cubic meters. The average concentration of long lived beta-gamma radioactivity on airborne particulates is presented in table 6 for 1966 and the first half of 1967.

Table 6. Beta-gamma radioactivity of airborne particulates, 1966 and January–June 1967

Location	Calendar year 1966		January-June 1967	
	Number of samples	Average concentration (pCi/m^3)	Number of samples	Average concentration (pCi/m^3)
Headquarters	706	0.18	353	0.68
NDFL	2,205	0.17	1,243	0.66

Water monitoring

Process water used at the NDFL is obtained from Ventura County Water District No. 10 and distributed onsite by the same piping system previously used when process water was supplied by onsite wells. Pressure is provided by elevated storage tanks, one 50,000-gallon and one 500,000-gallon tank onsite. While clinically potable, the water is not used for drinking. Bottled potable water is delivered by a vendor and is not analyzed. Water from the pipe system is sampled monthly at two locations. The average process water radioactivity concentration is presented in table 7.

Table 7. Process water radioactivity NDFL site 1966 and January–June 1967

Type of radioactivity	Calendar year 1966		January-June 1967	
	Number of samples	Average concentration (pCi/liter)	Number of samples	Average concentration (pCi/liter)
Alpha	24	0.13	12	0.09
Beta-gamma	24	4.6	12	3.4

Water samples are also collected monthly at Chatsworth Reservoir which is operated by the Los Angeles City Department of Water and Power. Normally, one water sample is obtained from the lake surface and a second sample is obtained from the reservoir water supply inlet located on the north side of the lake. The average radioactivity for both surface and supply water samples is presented in table 8.

Table 8. Chatsworth Reservoir water radioactivity 1966 and January–June 1967

Sample	Type of radioactivity	Calendar year 1966		January-June 1967	
		Number of samples	Average concentration (pCi/liter)	Number of samples	Average concentration (pCi/liter)
Lake surface	Alpha	12	0.32	6	0.29
	Beta-gamma	12	5.9	6	8.7
Supply inlet	Alpha	12	0.42	6	0.26
	Beta-gamma	12	5.9	6	6.5

Surface discharged waters from NDFL facilities drain into holding reservoirs on adjacent property. When full, the main reservoir is drained into Bell Creek, a tributary of the Los Angeles River in the San Fernando Valley, Los Angeles County. Pursuant to the requirements of Los Angeles Regional Water Quality Control Board Resolution 66–49 of September 21, 1966, an environmental sampling station has been established in Bell Creek Canyon approximately 3.4 miles downstream from the south NAA boundary. Samples obtained and analyzed monthly, include stream-bed mud, vegetation, and water. Average radioactivity concentrations in the main holding reservoir and Bell Creek samples are presented in table 9.

Table 9. Radioactivity in the Main Holding Reservoir[a] and Bell Creek, Atomics, January–June 1967

Sample description (units)	Number of samples	Alpha radioactivity	Beta radioactivity
Reservoir Station 6[a] (pCi/liter)	6	0.20	5.8
Reservoir Station 12[a] (pCi/liter)	5	.09	6.5
Bell Creek mud (pCi/g)	6	.38	24
Bell Creek vegetation (pCi/g ash)	6	.32	240
Bell Creek water (pCi/liter)	6	.05	7.3

[a] Locations not shown on figure 3.

Soil and vegetation monitoring

Soil and vegetation are regularly sampled at 24 locations. Twelve sampling stations are located within the boundaries of Atomics International's sites and are referred to as "onsite" stations. The remaining 12 stations, located within a 10-mile radius of the sites, are referred to as "offsite" stations.

Surface soil types available for sampling range from decomposed granite to clay and loam. Samples are taken from the top half-inch layer of ground surface. The soil samples are packaged and sealed in plastic containers and returned to the laboratory for analysis. Radioactivity in soil samples is presented in table 10.

Table 10. Radioactivity in the soil, Atomics 1966 and January–June 1967

Area	Type of radioactivity	Calendar year 1966		January-June 1967	
		Number of samples	Average concentrations (pCi/g)	Number of samples	Average concentration (pCi/g)
Onsite	Alpha	144	0.41	72	0.40
	Beta-gamma	142	29	72	27
Offsite	Alpha	48	0.44	24	0.37
	Beta-gamma	48	25	24	25

Vegetation samples obtained in the field are of the same plant type wherever possible, generally sunflower or wild tobacco plant leaves. These types maintain a more active growth rate during the dry season than do most natural vegetation indigenous to the local area. Vegetation leaves are stripped from plants and transferred to the laboratory for analysis. Plant root systems are not routinely sampled. Radioactivity in vegetation samples is presented in table 11.

Table 11. Radioactivity in vegetation, Atomics 1966 and January–June 1967

Area	Type of radioactivity	Calendar year 1966		January-June 1967	
		Number of samples	Average concentration (pCi/g ash)	Number of samples	Average concentration (pCi/g ash)
Onsite	Alpha	144	0.37	72	0.49
	Beta-gamma	144	169	72	425
Offsite	Alpha	48	0.37	24	0.33
	Beta-gamma	48	123	24	658

3. Feed Materials Production Center January–June 1967[4]

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the AEC. The location as related to populated areas is shown in figure 4. Cincinnati and Hamilton, the larger nearby communities, are situated 20 and 10 miles from the center, respectively. Operations at this project deal with the processing of high-grade uranium ores and ore concentrates to produce metallic uranium and with fabricating the metal into fuel elements.

During the many involved reactions and processes that lead to the production of reactor fuels, various liquid and airborne wastes are generated. These wastes contain varying quantities of uranium. Various in-plant methods are used to curtail their release into the environment surrounding the plant. Almost complete

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[4] Summarized from "Feed Materials Production Center Environmental Monitoring Semiannual Report for the First Half of 1967" (NLCO–1002).

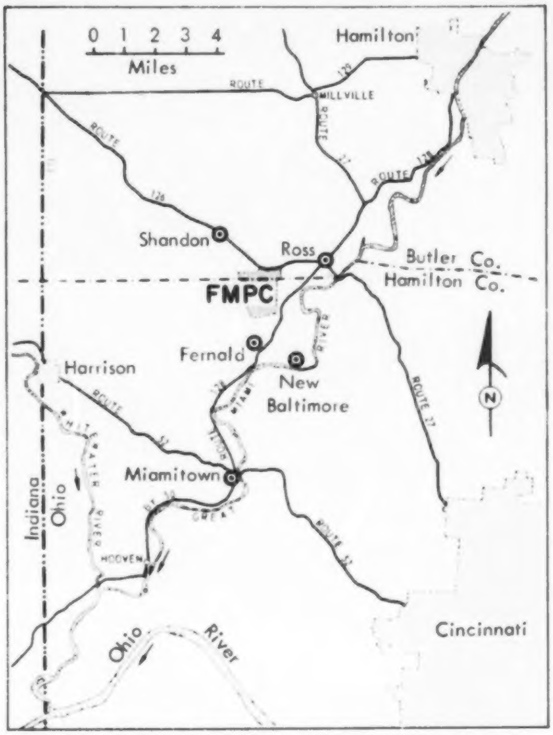

Figure 4. Area map of Feed Materials Production Center

removal of the materials is accomplished by using dust collectors and waste-treatment processes. In order to determine what concentrations reach the area surrounding the project an environmental survey program has been established which consists of water, soil, and air sampling of the environs and performing those analyses on the samples that are indicative of material released from the plants.

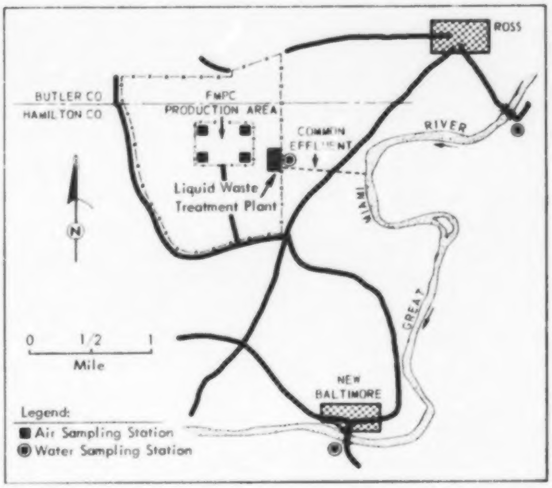

Figure 5. Air and water sampling stations, FMPC

Onsite air samples are obtained from four permanent perimeter air sampling stations, located at the four corners of the production area as shown in figure 5. Samples from these perimeter stations are collected once each week and analyzed for uranium and total radioactivity. Offsite samples are collected by a mobile air sampling unit. The location at which samples are collected is determined by local meteorological conditions on the day of sampling. Approximately 20 percent of all samples are taken upwind of the FMPC plant. Replicate samples are taken at each sampling point and averaged to obtain a representative concentration for that location. Concentrations of uranium and total radioactivity of airborne particulates sampled at onsite and offsite locations are given in table 12.

Table 12. Radioactivity levels of airborne particulates, FMPC, January-June 1967

Location	Number of samples	Uranium concentration[a] (pCi/m³)			Total radioactivity[b] (pCi/m³)		
		Maximum	Minimum	Average	Maximum	Minimum	Average
Onsite:							
Southwest	26	0.4	<0.1	0.1	1.1	<0.1	0.3
Northwest	26	.1	<.1	<.1	0.7	<.1	0.2
Northeast	26	.5	<.1	.1	1.1	.1	0.4
Southeast	26	.3	<.1	<.1	.6	<.1	0.2
All onsite samples	104	0.5	<0.1	0.1	1.1	<0.1	0.3
Offsite:							
0-2 miles from FMPC	27	.5	<.1	.1	1.1	<.1	0.2
2-4 miles from FMPC	48	.3	<.1	<.1	4.4	<.1	0.4
4-8 miles from FMPC	28	.1	<.1	<.1	9.7	<.1	1.4
8-12 miles from FMPC	12	<.1	<.1	<.1	5.1	<.1	1.1
All offsite samples	115	0.5	<0.1	<0.1	9.7	<0.1	0.7

[a] AEC radiation protection standard, 2 pCi/m³.
[b] AEC radiation protection standard, 100 pCi/m³.

Water monitoring

Each of the individual production plants on the project has collection sumps and treatment equipment to remove the uranium from the process waste water. The effluent from the plants are collected at a general sump for equalization and settling. The clear water from the sump is pumped to the river. The solid portion is pumped to a chemical waste pit for further settling. The flow, which is decanted to the clear-well portion of the pit, is virtually free of solids and radioactivity. The effluent from the sump and clear well are combined with waste water from the FMPC water treatment plant, sanitary sewage treatment plant, and storm sewerage system and discharged via a common effluent outfall into the Great Miami River. A weir-type water sampler collects samples of the combined effluent stream, which are removed and analyzed daily. These results are utilized with measurements of river flow in calculating the radioactive contaminant concentrations added to the river. Weekly spot samples are also obtained upstream and downstream from the common FMPC effluent at locations shown in figure 5. The results of the FMPC water monitoring program for January–June 1967 are summarized in table 13.

Table 13. Radioactivity in the Great Miami River FMPC, January–June 1967

Location	Number of Samples	Uranium concentration[a] (pCi/liter)			Total radioactivity[b] (pCi/liter)		
		Max.	Min.	Average	Max.	Min.	Average
Sewer outfall	181	<10	<10	<10	40	<10	<10
Upstream from outfall	26	<10	<10	10	120	<10	30
Downstream from outfall	29	140	<10	12	340	<10	40

[a] AEC radiation protection standard, 20,000 pCi/liter.
[b] AEC radiation protection standard, 3,000 pCi/liter.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–June 1966	April 1967
July–December 1966	August 1967

4. National Reactor Testing Station[5] January–June 1967

Idaho Operations Office-Health Services Laboratory
U.S. Atomic Energy Commission
Idaho Falls, Idaho

Data from the environmental monitoring network on and around the National Reactor Testing Station (NRTS) in eastern Idaho revealed that NRTS operations during the first half of 1967 did not contribute significantly to environmental radiation or radioactivity concentration levels. These levels remained well below the levels defined as thresholds of concern by the Federal Radiation Council (FRC). The radiation protection standards used at the NRTS, which are established in AEC Manual Chapter 0524, are based on FRC recommendations. In choosing applicable standards for drinking water, credit has been taken for the fact that no significant quantities of radium-226 or radium-228 have been released to the environs by NRTS operations. The concentrations of radioactivity reported include contributions from all sources. No attempt has been made to separate radioactivity contributed by NRTS operations from that contributed by natural sources of radioactivity or by fallout from weapons debris. Samples of air, water, and milk are collected routinely at stations shown in figure 6. The results of the analyses performed on these samples are shown in table 14.

Offsite water monitoring

Low-level wastes from various operating facilities at the NRTS are released to the groundwater table through disposal wells and ponds located near each facility. Before disposal the liquid wastes are carefully monitored at the

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[5] Summarized from "Environmental Monitoring Report No. 20, First and Second Quarter 1967" U.S. Atomic Energy Commission, Idaho Operations Office, Health and Safety Division, National Reactor Testing Station.

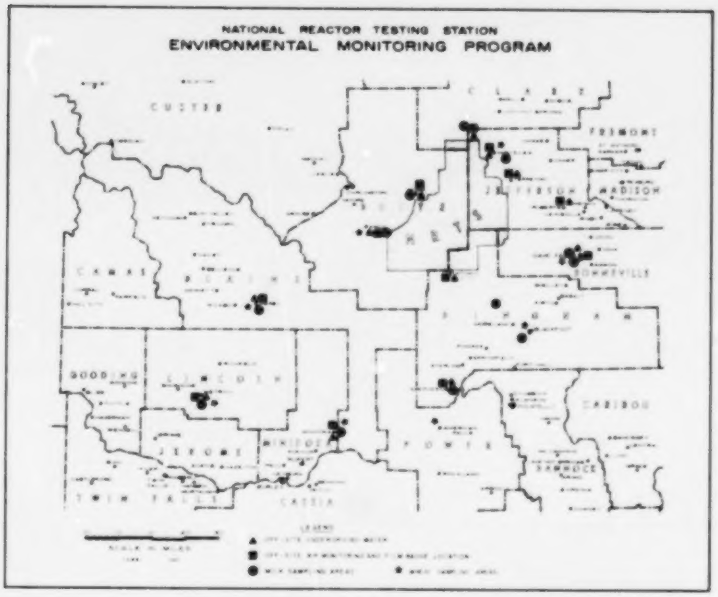

Figure 6. Environmental monitoring stations, National Reactor Testing Station

NRTS and, as an added safeguard, offsite underground water samples are collected and analyzed regularly from those populated areas nearest the site boundaries. Samples from these locations, as shown on the accompanying map, plus the onsite samples provide adequate information on the underground water leaving the NRTS. During January–June 1967, one sample was collected from each of 12 sampling stations. The average concentrations of alpha and beta-particle emitters were less than 4 percent and 8 percent of the respective radiation protection standards. The alpha radioactivity is attributed primarily to radioactive elements which are naturally present in the environment.

Onsite water monitoring

Onsite samples were taken from the plant production wells in order to detect and define possible sources of contamination. During January–June 1967, 205 samples were collected from 22 sampling stations, most on a biweekly basis. Analyses of these samples showed that average concentrations of alpha and beta-particle emitters were no more than 0.1 percent and 0.3 percent of their respective AEC standards.

Air monitoring

During January–June 1967, 207 air samples were collected and evaluated for airborne alpha-particle emitters. A gross alpha-particle determination was made on filter-paper samples after a sufficient time had elapsed to permit the decay of the short-lived daughter products of radon and thoron. The filter-paper samples were counted for alpha-particle emission by scintillation counters. The average measured concentrations of alpha radioactivity in air was .002 pCi/m^3 or 5 percent of the AEC standard. The radiation protection standard used is that for uncontrolled areas and for gross alpha radioactivity for which no analysis for specific isotopes have been made. The alpha radioactivity is attributed primarily to long-lived radioactive elements naturally present in the environment.

Results of the data reported from the 12 offsite radiation telemetry stations indicate

Table 13. Environmental monitoring data for the National Reactor Testing Station January–June 1967

Type of sample and units	Number of stations	January-June 1967					
		Approximate frequency of collection	Type of analysis	Minimum level of detection	Maximum radioactivity of single sample	Average radioactivity per sample	AEC radiation protection standard
Offsite underground water, (pCi/liter)	12	Semiannual	Alpha	3	5	<4	100
			Beta	6	15	<8	100
Onsite production well water, (pCi/liter)	22	Biweekly	Alpha	3	9	<4	3,000
			Beta	6	13	<7	3,000
Offsite air, (pCi/m^3)	12	Continuous	Beta-gamma	1.6	16	<3	100
			Iodine-131	3.6	24	<4	100
Offsite milk, (pCi/liter)	12	Monthly	Iodine-131	20	49	<21	100
			Strontium-90	1.5	8	<6	200
Offsite area monitoring badges, (mR)		Semiannual	Gamma	10	70	<48	170/yr

that the average concentrations of gaseous iodine–131 and particulate gross beta radioactivity in the atmosphere were less than 6 percent of the AEC radiation protection standards.

Offsite milk monitoring

Routine analyses of iodine–131 and strontium–90 concentrations in milk continued during January–June 1967. Of the 72 routine radioiodine analyses, only 4 samples were found to have concentrations greater than 20 pCi/liter. As indicated in table 14, the average iodine–131 levels do not exceed 21 percent of the AEC standard. Strontium–90 concentrations in 12 samples showed the maximum radioactivity to be 8 pCi/liter or 4 percent of the AEC standard with an average value of less than 6 percent of this standard.

Gamma radiation levels

Seminannual measurements of external gamma radiation levels were made with thermoluminescent dosimeters (TLD) at 12 offsite locations during the first half of 1967.

Natural background radiation levels at TLD locations vary, but studies made prior to nuclear operations at the NRTS showed that normal background levels were of the order of 100–150 mR/yr. This indicates that NRTS operations have added no significant radiation to surrounding areas.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–June 1966	March 1967
July–December 1966 and calendar year 1966	September 1967

Reported Nuclear Detonations, February 1968

The U.S. Atomic Energy Commission announced two underground nuclear tests conducted at its Nevada Test Site during February 1968.

The test of February 21 was a low-intermediate yield test (equivalent to 20 to 200 kilotons of TNT). An underground nuclear test of low yield (less than 20 kilotons TNT equivalent) was conducted on February 29, 1968.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

POLONIUM-210 IN TOBACCO. *Stuart C. Black and Erich W. Bretthauer. Radiological Health Data and Reports, Vol. 9, March 1968*, pp. 145–152.

Variations of polonium-210 content in tobacco, the amount of polonium-210 in various fractions of smoked cigarettes and changes in polonium-210 content of mainstream smoke caused by variation in the smoking procedure have been determined. The average polonium-210 content for whole cigarettes was found to be 0.483 pCi/gram and 0.477 pCi/gram for butts. No polonium-210 enrichment in the butt of cigarettes during smoking was found. Polonium-210 content and concentration in mainstream smoke increases with puff size.

KEYWORDS: cigarettes, mainstream smoke, polonium-210, puff size, smoking machine, tobacco.

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